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ENGINEERING:

An Illustrated Weekly Journal.

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HORIZONTAL 50 HP. ENGINES, 120 lb. pressure, 150 revs. per minute.

Four LEATHER LINK BELTS, 10 in., 54 ft. long.

90 ft. of HEAVY IRON RAILING round ENGINES, with two gates.

Can be seen in work by appointment at the Royal Edinburgh Asylum for the Insane, Morningside, Edinburgh.

Offers to be lodged with R. SCOTT MONCRIEFF, W.S., 28, Rutland Square, Edinburgh. E 400

For Sale, Two New Extra

HEAVY STEEL BOGIES, each capable of carrying 40 tons; carried on six wheels (solid). Wheels 9 in. diameter, gauge of bogie 7 ft. 3½ in., rails on top side of bogie 7 ft. 8½ in. gauge, overall dimensions of frame 8 ft. by 7 ft., height from rail to top of bogie 12½ in. Suitable for iron and steel works or boiler works. Can be seen by appointment.—Apply to the NEWCASTLE ALLOY CO., LTD., Milburn House, Newcastle-upon-Tyne. E 443

For Sale, Four Horizontal

BORING MACHINES, suitable for 18 Pdr. H.E. Shells; massive in design and made specially for heavy work.

One BAR TURNING MACHINE, for rough turning Bars from 3½ in. to 3¾ in. diameter.

One MECHANICAL RIVETING MACHINE, for riveting Base Plates in 18 Pdr. Shells.

One COPPER BANDING PRESS, for 18 Pdr. Shells.

Can be seen at work up to 30th June, 1916, at Messrs. JOHN WOOD & SONS, LTD., Wigan. E 446

Lathe for Sale :—

Massive 16 in. Centre Lathe, S.A.S. & S., faceplate, 5 ft. dia., with removable rallling attachment and slotted table, compound slide rest, five-speed cone, overhead gear.

JOHN F. WAKE, Darlington.

Steam Engines for Sale :—

Modern type Horizontal Cross Compound Engine, by Hayward Tyler; cylinders 16 in. and 26 in. by 32 in. stroke. Sensitive Governor, Rider's Expansion Gear, Flywheel 11 ft. by 18 in. turned face. In excellent condition. £350.

Self-contained Horizontal Compound Jet Condensing Engine, by Jas. Milne; cylinders 12 in. and 21 in. by 24 in. stroke, flywheel &c., and geared countershaft.

Horizontal Engine, by M. Rly. Co., cylinder 18 in. by 26 in. Pickering Governor, heavy flywheel. £100.

Horizontal Engine, by Hick Hargreaves, cylinder 18 in. by 36 in. stroke, Corliss Valve. Fine engine. £250.

Horizontal Engine, by Robey, cylinder 13 in. by 26 in., Pickering Governor, heavy flywheel, together with Vertical Feed Heater. Fine modern engine. £100.

Two Vertical High Speed Compound Engines, by Gwynne, cylindrs 12 in. and 18 in. by 9 in. stroke. £180 each.

JOHN F. WAKE, Darlington.

THE BRAZILIAN SUBMARINE DEPÔT MOTOR-SHIP "CEARA."

THE modern submarine, with its wide sphere of utility and efficiency, is still relatively a delicate weapon, being fitted with a great mass of machinery, which is light and intricate, in order to conform to the rigid limitations of space and weight available. The conditions under which the crew must work are also exceedingly arduous. Thus it is necessary that every submarine fleet must operate from a well-equipped base, if its activity and effectiveness are to be maintained at a reasonable maximum. This refers equally to *matériel* and *personnel*. If the base is capable of movement, as in the case of a depôt ship which may be said to form the base, the effectiveness and utility of the fleet of submarines are enhanced and the field of operation widened.

The Brazilian Navy includes a number of submarines of the well-known Laurenti type, built by the Fiat San Giorgio Company, of Spezia, Italy, and as a depôt ship for this flotilla the same company has recently completed the Ceara, which we illustrate this week on Plates XLVIII. and XLIX. Briefly, such a ship must be able to accommodate besides its own crew, the officers and crews of the submarines attached thereto, to carry all stores required, including fuel and lubricating oils, torpedoes and spare gear, be able, if required, to charge the batteries, or to fill with compressed air the reservoirs of the submarines, and have a workshop completely equipped for carrying out extensive repairs to the machinery. This generally can readily be done, and, as our illustrations show, is accomplished in the Ceara, in which also other features of great interest are to be noted. Apparatus is installed for subjecting the hulls of submarines to pressure tests in order to locate leaks in the hull, &c. Furthermore, the construction of the Ceara permits of the dry docking of any one of the units of the flotilla, and, if necessary, of raising the submarine, prior to docking, by means of two cranes at the stern. For this last-named purpose all the submarines attached to this ship, and indeed all the Fiat San Giorgio's submarines, have a lifting-eye for the attachment of raising gear.

The leading dimensions of the Ceara are: Length, 328 ft.; breadth, 51 ft.; depth, 27 ft.; the displacement tonnage is 4130 tons, and the speed 14 knots. The profile, Fig. 1, on Plate XLIX., shows the general arrangement and the bulkhead divisions of the ship. The lines of the ship are given in Figs. 2 to 4, also on the same plate, and are of special interest owing to the adoption of a double stern, in order to form the cylindrical chamber for the dock. The gradual way in which the section changes is worthy of note. The cross-sections, Fig. 5, on Plate XLIX., and Figs. 6, 7, and 8, on Plate XLVIII., are the most interesting illustrations, as they show the division of the ship for the dock. Fig. 5, which is a half section at the bridge and a half section at the machinery space, shows in much detail the scantlings of the ship; accompanying it are tabulated particulars of the hull, interior dock, chains, cables, riveting, &c. It is not, therefore, necessary to deal further with the construction of the hull.

The sections, Figs. 6 to 8, on Plate XLIX., are respectively at frames 8, 30 and 52, reckoning from the stern, and show the arrangement for the docking of submarine-boats. The dimensions of the dock are:—Diameter at entrance, 24 ft. 9 in., tapering down, in a length of 16 ft. 7 in., to a diameter of 23 ft. 4 in., which is continued for a length of nearly 140 ft., when there is again a tapered end forward, according to the dimensions given in the section, Fig. 5. The total length of the dock is 210 ft., sufficient to dock any one of the units of the flotilla. The dock extends from frame 30 to frame 125, the frame spacing being 2 ft. 2¾ in. Fig. 7 shows the circular door closing the dry dock. Fig. 8 is a section further forward—at the machinery space—showing the position of the dock amidships. The constructional details of the dock are noted on the main section, Fig. 5, on Plate XLIX., and the accompanying tabular statements. Permanent blocks are provided for the accommodation of the submarine-boats. There are two centrifugal pumps, each with a capacity of 300 tons per hour, for filling or emptying the dock. There are connections also to the tanks, bilges, &c.

Fig. 6, on Plate XLVIII., shows the double stern construction to provide entrance to the dock with the lattice bracing between, and the cranes on the deck level for raising submarine-boats. We defer the description of the latter for another article, when illustrations will be given. Meanwhile it will be obvious that there were involved two rudders as well as twin-screws. With this type of divided stern the free flow of water to the propeller makes for good propeller efficiency. Each of the rudders is driven by Hele-Shaw electric-hydraulic gear. In Fig. 6 also the hand steering gear is shown in compartment 16, and on the main deck towing gear is installed. The guide-sheaves of the main cranes are also seen in this view.

Each stern, it will be seen, is bossed out to carry the propeller shafting. The main engines, amidships, as shown in Fig. 5, were built by the Fiat San Giorgio Company, of Turin, and were fully described in ENGINEERING of February 25 last. The leading features may, however, be recapitulated. These, it will be remembered, are the largest marine Diesel engines afloat, and work on the two-cycle reversible principle, each having six working cylinders of 630 mm. (24.8 in.) diameter by 900 mm. (35.4 in.) stroke, developing for each engine 2300 brake horse-power at 130 revolutions per minute, or 2100 brake horse-power at 114 revolutions per minute. The total brake horse-power aboard is 4600, equivalent to about 6300 indicated horse-power. As explained in the former article, the engines have the advantage of small size and light weight for their power, advantages of considerable moment in this particular application, as will be seen from the limited space available and from a consideration of the particular advantages with this ship accruing from small size. Each engine drives a propeller of 11 ft. diameter with a pitch of 14 ft. 3 in., giving the vessel a speed of 14 knots. It might here be mentioned that most successful trials have been carried out with this vessel, for manœuvring, reversing, &c., including a 24 hours' trial at sea at full power.

In midship section (Fig. 5) the construction of the seating for the main engines can be seen. The longitudinal engine girder is carried down to the outer hull, and the space between the girders forms a tank, with a top under the engine bed-plate, dished to give the maximum capacity.

The profile and the various sections, along with the view of the ship, Fig. 9, on Plate XLVIII., afford an idea also of the general arrangement of the interior. Accommodation is provided for the officers and crew of six submarines of about 260 tons surface displacement. Light guns are mounted fore and aft. A wireless installation is fitted (Fig. 1). Four motor-boats are also carried, two of 30 ft. and two of 21 ft., each with petrol engines of the well-known F.I.A.T. type. There are, further, two boats for divers, and four lifeboats. The steel masts are 3 ft. in diameter, and on the main mast two derricks for handling cargo are provided (Fig. 8). Six smaller derricks are attached to the ventilators. The two forward winches, electrically driven, handle each three tons. At the bow and at the stern are two windlasses for ⅝ in. chains for mooring the ship, and in the case of the aft pair for assisting to dock the submarines. There are four electrically-driven capstans.

(To be continued.)

LIFT-LOCKS ON THE TRENT CANAL, CANADA.*

(Concluded from Page 550.)

DETAILS of the gates used to close both the chambers and the reaches present certain new and interesting features, which are fully illustrated in Figs. 19 to 22, page 570, and Figs. 23 to 32, page 571. Each gate is made up of three main 15-in. channels, with a small plate and angle girder at the top, and is stiffened vertically by 10-in. I-beams. In every space between these vertical I-beams there are placed two galvanised-iron air-chambers about 11 ft. long (see Figs. 19 and 22). These have the effect of making the gates practically buoyant, and this decreases markedly the amount of work which has to be done in raising the gates from a horizontal to a vertical position. The water-tight plating is, in each case, on the outside of the gate, and the hinges are at the bottom. In the case of the lower reach-gates and chamber-gates, the hinge for the reach-gate is 2 ft. 4 in. below the hinge of the chamber-gate (see Fig. 20), and 1 ft. 10 in. separates them in a longitudinal direction. Consequently the chamber-gate is approximately 10 ft. deep, while the reach-gate is about 12 ft. 6 in. deep. As it is never necessary to operate any gate singly, the gates are arranged to work in pairs. The reach-gate mechanically actuates the lock-gate in the following manner. At each end of the reach-gate there is a pinion meshing into a circular rack, set into the dock wall (Fig. 20). The centre of the pitch circle of this rack is, of course, coincident with the centre of the hinge of the reach-gate. The pinions above referred to are connected by a horizontal shaft running right across the gate (Fig. 19), and power is applied to this shaft by means of a sprocket with chain, driven from another shaft, the centre of which is the same as that of the hinge. The bracket supporting this shaft is shown in Figs. 23 and 24. As mentioned elsewhere, this shaft is actuated by one of the hydraulic gate engines provided. The chamber-gate is operated from the reach-gate by a simple roller engagement between them, and it is thus unnecessary to apply any separate operating device to the chamber-gates. This roller is shown in the upper right-hand corner of Fig. 20. The locking device for the chamber-gates consists of a folding clevise on the chamber plating, which is capable of being moved longitudinally by a ratchet-actuated screw. The clevise engages an eye-plate on the gates by means of a movable pin. The whole is shown in Figs. 25 to 27, page 571.

The seal between the reach-gate and the reach is accomplished by a small rubber strip, which, lying over the adjacent surfaces, is made water-tight by hydrostatic pressure (see Fig. 28). A similar arrangement is used for making the joints between chamber-gate and chamber water-tight. The seal between the end of the chamber and the end of reach is accomplished by a collapsible rubber tube, Fig. 29, which, when the chamber is away from the reach, lies almost flat against the end of the reach-gate frame. When, however, the chamber is in its proper position the tube is inflated by compressed air at 90 lb. per sq. in., and a water-tight joint is obtained. Further details of this joint tube for the lower reach and chamber-gates are shown in Figs. 30 to 32. A cross-section of the collapsible rubber tube is represented in Fig. 31.

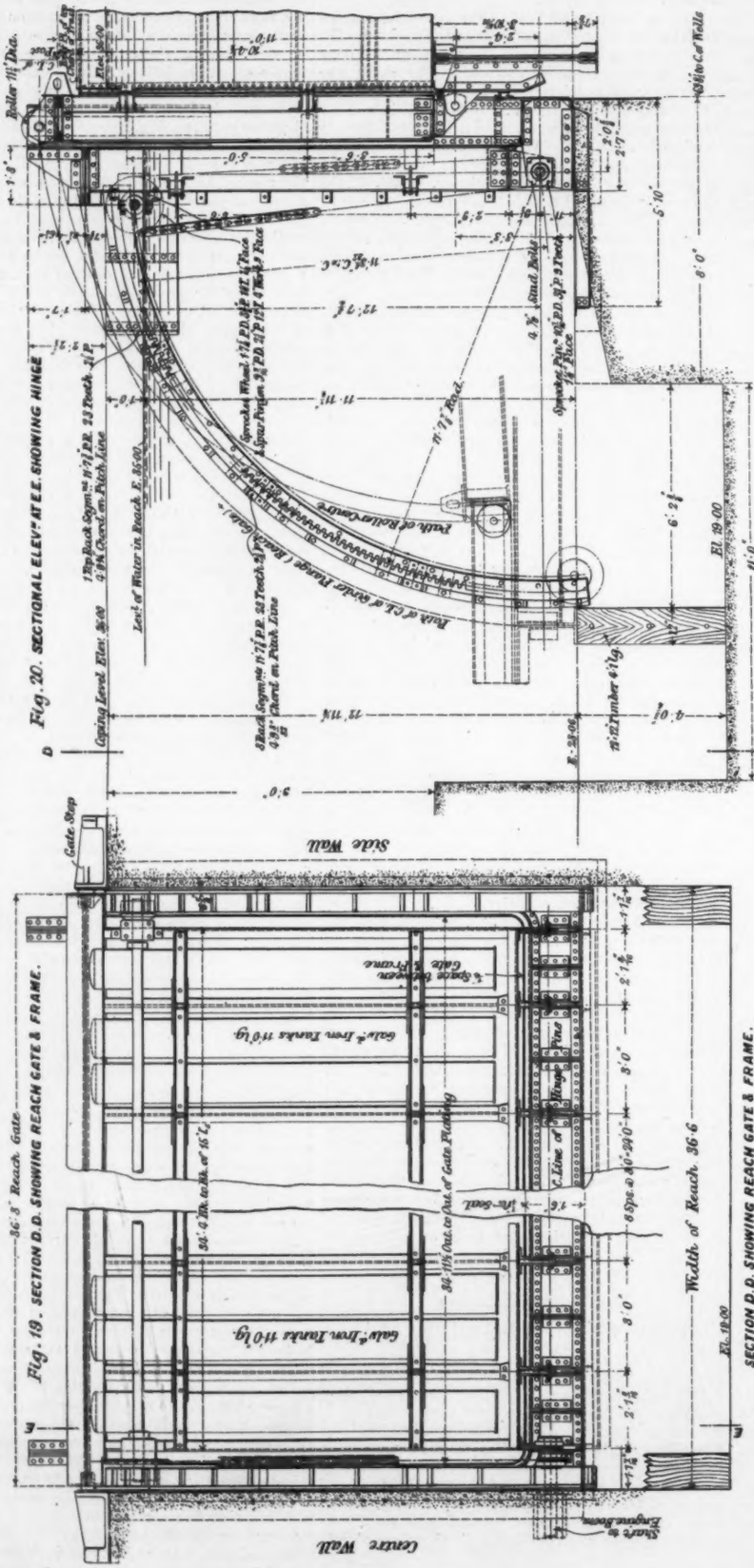
The main presses, which had, at the time of their construction, the distinction of being the largest presses that had yet been made, are plain steel castings, built up in flanged sections, 5 ft. 3 in. long. They are represented in detail in Figs. 33 to 43, Plate L. The inside diameter is 7 ft. 8½ in. and the metal is 3½ in. thick. The packing between sections was felt by the engineers to be a very important feature of the design, since the rectification of any leakage that might have developed would have been a most expensive and difficult operation. Extensive experiments were consequently conducted until the arrangement shown in Figs. 34 to 37 was finally adopted. The specification only called for a single copper packing of the type indicated in Fig. 36, but while this was apparently sufficient, the engineers felt that the extra cost of the additional lead ring shown just inside the bolts, Figs. 34 and 35, and also in Fig. 37, would be well repaid in the increased security given by its use. Each press terminates, of course, in a large stuffing-box surrounding the ram, and the by-pass connecting the presses heads into an annular space just below the stuffing-box, which permits an ample flow of water to or from the press. The by-pass itself consists of a 12-in. lap-welded wrought-iron pipe provided with a main gate valve and two auxiliary emergency valves, to which reference has already been made.

The rams are built of cast iron in flanged sections, 5 ft. 3 in. long. The flanges are, naturally, on the inside, and the finished outside diameter of each

* On page 549 of our last issue, third column, line 13 from the top, for "Darlington" read "Anderton."

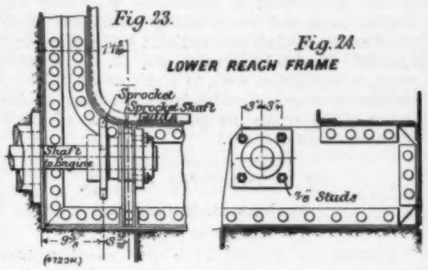
LIFT-LOCKS AT PETERBOROUGH, ON THE TRENT CANAL, ONTARIO, CANADA.

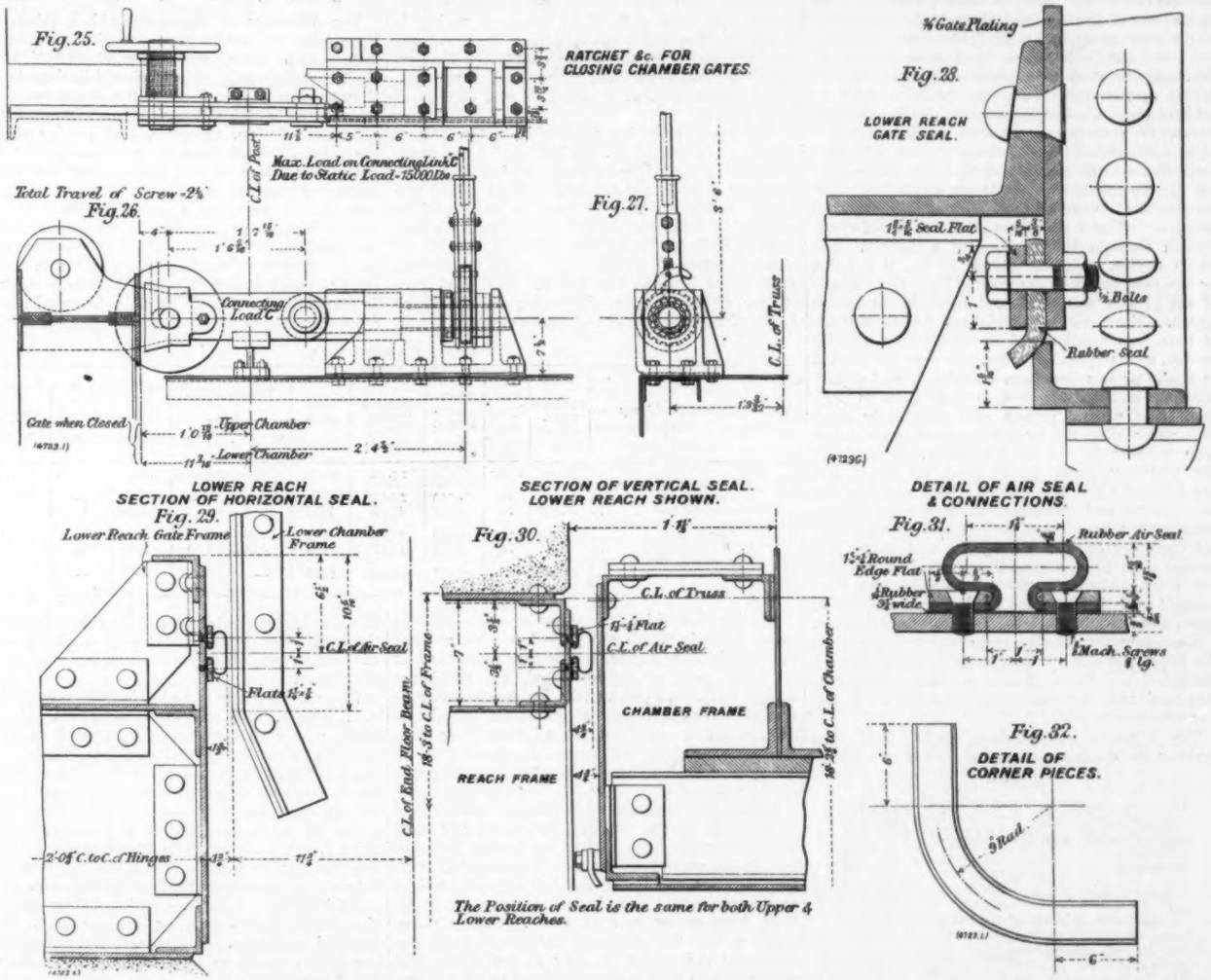
DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY, LTD., ENGINEERS, MONTREAL, CANADA.



section is 90 in. There is, consequently, a water space of 1¼ in. completely around the ram, the walls of which are 3½ in. thick. The joints between the ram sections are made in a similar fashion to those of the presses, with the exception that the lead ring was omitted. The stroke of the ram is 65 ft. The by-pass entry is at E, Fig. 33, and the methods of sealing the west and east cylinders to their base-plates are shown in Figs. 41 and 42 respectively.

All the castings of the presses and the rams were subjected to rigid hydraulic tests at a gauge pressure of 1200 lb. per sq. in., which was about twice the working pressure. A certain number were, moreover, tested to 2000 lb. per sq. in. gauge pressure, and these latter proved so satisfactory that it did not appear to be necessary to continue the tests beyond this limit. Ordinarily one press and one ram section were tested together by being bolted





to strong frames going over the ends. Five circumferential tapes were placed around the press with equidistant vertical spacing. These served to measure the expansion at all points of the press, while the compression of the ram was measured by accurate inside micrometers reading to $\frac{1}{1000}$ in. The results of the tests of the presses invariably showed the greatest extension of the steel toward the middle of the section and practically no extension of the metal in the vicinity of the flanges. Corresponding conditions existed in the case of the cast-iron ram sections, where the greatest diminution of diameter occurred at the centre of the section, while, as before, the flange regions were not affected. The conclusions to be drawn from the tests of the presses, which were of unannealed cast steel, may be summarised as follows:—

1. It is possible to obtain steel castings in this form which are absolutely impervious to water up to 2000 lb. per sq. in. gauge pressure.

2. It is possible to get perfectly homogeneous castings.

3. That a slight permanent set occurs at about 300 lb. per sq. in. gauge pressure, although part of this may only be apparent owing to the self-adjustment of the tapes.

4. Increased pressures up to 1200 lb. per sq. in. gauge pressure, or repeated applications of them, do not affect this slight set.

The conclusions to be drawn from the tests of the cast-iron ram may be summarised thus:—

The absence of an elastic limit in compression for cast iron cannot be ignored in castings of these dimensions. As a result of this a well-recognised permanent set occurred in all castings. The mid-diameter of ram sections was accordingly increased in manufacture, so that under working conditions, the whole ram might have its true theoretical diameter.

The auxiliary mechanical operating equipment of the lock includes hydraulic pumps (turbine-driven) with accumulators and their accessories, an air-compressor, hydraulic gate engines, hydraulic capstans and an air-water lift.

The pumps are used to supply water under pressure to an hydraulic accumulator operating at 640 lb. per sq. in. gauge pressure, the ram of which has a diameter of 20 in. and a working stroke of 30 ft. 6 in. These pumps, of which there are two in all, are of the three-throw single-acting type, and are driven through reducing gears by a 15-in. Crocker turbine, working under 65 ft. head. Water is supplied by the accumulator to the hydraulic gate engines, hydraulic capstans, or to the main presses to adjust the relative heights of the chamber, or, indeed, if necessary, to operate only one chamber of the lock in the case of accident to the other.

The air-compressor (built by the Taylor Hydraulic Air-Compressor Company) is of the usual hydraulic type and is capable of supplying 330 cub. ft. per minute at a pressure of 28 lb. per sq. in. This machine supplies air to the collapsible tube seal and to the air-water lift.

Each hydraulic gate engine has three cylinders. One engine is used to operate the lower gates and one the upper. Each actuates a horizontal countershaft, to which reference has already been made, and this actuates the reach-gates gear by means of a sprocket and chain. There is one hydraulic capstan at the lower reach and one at the upper, to enable the operator to handle barges, &c., more expeditiously. The air-water lift, receiving its supply of air from the compressor, is entirely automatic and is used to drain the chamber-pits.

The above-mentioned pumps, accumulator, air-

compressor, and the electric-light generators (turbine-driven) are located in the pump-room, which is formed within the main concrete breast-wall. This room, about 12 ft. wide, 17 ft. high and 110 ft. long, is situated about 15 ft. above the bed-rock.

The operator's cabin is situated at the top of the centre tower and commands a perfect view of the lock. Within the cabin are located the levers necessary to control the working of the lock. These levers are all interlocked, and consequently the operations cannot be performed in wrong order. In this way the designers of the lock have obviated any possibility of dangerous breakage due to mistakes on the part of the operator.

The erection of the concrete work presented no great difficulties. Concrete was deposited into forms from aerial cableways suspended between two towers on each side of the lock. For the erection of the steel and iron work a siding was run up the side of the lock and all material handled by 15-ton stiff-leg derricks. All field riveting, reaming and caulking were done with compressed air, furnished by a 55-horse-power compressor, steam-driven and located beside the pits. A very ingenious device used on the erection was a pneumatic wrench for screwing up the nuts on all bolts up to 1⅛ in. in diameter. On the large presses and rams there was a large number of these bolts, and the use of the machine saved a great deal of time. It consisted, essentially, of an oscillating double-acting air-cylinder, the piston of which rotated a box-wrench through the medium of a ratchet. The whole device, weighing about 70 lb., is handled by two men and does the work of 25. The erection of the presses was conducted through the winter season. Each section, weighing on an average 10 tons, was handled and lowered with a stiff-leg derrick, steam-operated. The rams were not erected until the presses had been completed, and a quite ingenious method was used to place these in position. One of the presses was completely filled with water after the by-pass connecting them had been temporarily closed. The base section of the ram was then placed in the press, its weight still being carried by the derrick. The packing was then placed and the gland screwed down. After checking the tightness of all hydraulic connections, the derrick gradually released its hold of the ram section until it rested upon the confined water within the press. The adjacent ram section was then brought and fitted to the base section already in place, and the joint between them carefully finished.

Enough water was then permitted to escape from the press, allowing the ram to settle down through the gland the depth of each section. Successive ram sections were thus erected until the whole ram was complete in place.

The following general data on the lock may, perhaps, be of interest:—

Weights.

	Lb.
Presses and rams	1,062,515
Trusses and chamber	1,281,462
Guides, gates, and other structural work	400,749
Machinery	149,488
Total weight of metal	2,894,214

Comparative Figures of Hydraulic Lift-Locks.

	Lift in Feet.	Length of Chamber	Width of Chamber	Navigable Depth of Water.
		ft.	ft.	
Peterborough ...	65	140	33	8 ft. 10 in.
La Louviere (abt.)	50	140	19	7 ft. 10 in.
Les Fontinettes (abt.)	50	140	19	7 ft. 10 in.

Time of Lockage.—The average time required to pass a vessel through the lock is 10 to 12 minutes, while the record time for the same operation is 6½ minutes.

As already mentioned, two of these locks were provided, namely, at Peterborough and Kirkfield. That at Peterborough we have described in detail above, while that at Kirkfield is represented in Fig. 44, on page 578. It is very similar to the Peterborough Lock, with the exception that steel has been used for the towers instead of concrete, and the upper reaches are carried over the roadway by a steel viaduct. Mr. Walter J. Francis, M.Inst.C.E., was the consulting engineer for both the locks and, as mentioned above, Mr. R. B. Rogers was the superintending engineer for the Government. The whole of the metal work in connection with both the Peterborough and the Kirkfield Locks was fabricated and erected by the Dominion Bridge Company, Limited, Montreal, Canada, and 15, Dartmouth-street, Westminster, S.W., to whom we are indebted for the drawings and particulars which have enabled us to prepare the foregoing account of these interesting installations.

ON REDUCTION GEARS.

By JOHN H. MACALPINE.

(*Concluded from page 549.*)

Boiler-Room Weights.—For the geared turbine over the triple and quadruple-expansion engines Messrs. McLaren and Welsh credit a saving in weight in the boiler-room varying from 8.9 per cent. in a ship of 10 knots speed, 2020 tons displacement, and 560 shaft horse-power, to 17.8 per cent. in a 16-knot ship, of 11,520 tons and 6850 shaft horse-power.*

The steam, including auxiliaries, in the 10-knot ship is given as 16.4 lb. per indicated horse-power per hour for the triple-expansion engine, and 17 lb. per shaft horse-power per hour for the geared turbines. While the 16.4 lb. may be considered an economical result, the 17 lb. can, as we have seen under *Efficiency*, be brought down to 14 lb. by higher peripheral speed and double reduction. This would increase the 8.9 per cent. saving to 30 per cent. or more, depending on the exact design of the boilers and accessories adopted.

more difficult to follow. I reproduce these, together with the engine-room weights, in a table of ship and machinery data subjoined.

Messrs. McLaren and Welsh do not give the data for geared turbines of Ship III., as they believe "no appreciable improvement can be shown, either in steam consumption per shaft horse-power or in propeller efficiency, if gear-wheels of practicable dimensions are to be fitted."

The conclusions regarding the three ships seem to me inconsistent. There is a difference in the fineness of the ships, Ship II. being the finest; but as that principally affects the shaft horse-power, I have omitted it. Ship II. is, relatively to her size, the fastest, and the corresponding speeds, taken in proportion to the square roots of their lengths, are:—

Ship I.	22.2
„ II.	16.0
„ III.	24.0

The difference of fineness would, I think, still leave Ship II. at 22 knots relatively much the fastest ship. Also, the steam consumption per shaft horse-power on Ship II. should be very nearly, if not quite, as good with the direct-connected turbines as in Ships I. and III. Allowing for all questions of ship, propeller, and turbine design, the point at which there is no advantage for full-power conditions of the geared over the direct-connected turbine should be reached first by Ship II. If we adopt a power constant of 4, or even of 3, and reduce to three or even to two shafts, the gear-wheels for Ship III. are entirely reasonable. Apart from the decreased water rate, a great saving, which makes it eminently worth while to fit geared turbines, comes from the decreased engine-room weights, as we shall see in the next section.

SHIP AND MACHINERY DATA.

Ship.	Type of Machinery	Displacement.	Speed.	Shaft-Horse-Power.	Heating Surface.	Grate Area.	Boiler-Room.		Engine-Room and Tunnel.		Water per Shaft Horse-Power per Hour.
							Weight.	Saving.	Weight.	Saving.	
		tons	knots		sq. ft.	sq. ft.	tons	per cent.	tons	per cent.	lb.
I.	Four-shaft direct-connected turbines ..	22,300	20	24,500	58,050	1386	1890	—	1070	—	13.2
	Geared turbines	22,300	20	21,000	48,370	1155	1570	16.9	1050	1.9	12.6
II.	Three-shaft direct-connected turbines ..	2,380	22	9,850	18,700	540	580	—	280	—	15.5
	Geared turbines	2,380	22	8,250	14,170	405	470	19.0	280	0	13.2
III.	Four-shaft direct-connected turbines ..	29,550	24	42,100	101,440	2425	—	—	—	—	13.0

Leaving out this slow ship, in the remaining seven cases in which the geared turbine replaces the reciprocating engine, the average saving is 15.4 per cent. and, as before stated, the maximum saving is 17.8 per cent.; the average steam consumption per shaft horse-power of the geared turbine is 14.3 lb. per hour, which, as we have seen, can be much improved upon. It would then be nearer the truth to place the average saving well over 20 per cent.

Replacing combined reciprocating engines and turbines by geared turbines, the steam per shaft horse-power per hour is given by Messrs. McLaren and Welsh as 13.6 lb. for the former and 12.9 lb. for the latter, and the saving in boiler-room weight as 6.8 per cent. This is a large ship of 33,000 shaft horse-power and 21 knots. Thus we can safely reduce the estimated water rate to 12 lb., increasing the saving to fully 12 per cent. The saving in this case is comparatively small, as combined reciprocating engines and turbines make an efficient though heavy propulsive unit.

The results with regard to the replacement of direct-connected turbines by geared turbines are The number of shafts can also be reduced, making the machinery much less complex. Both these advantages will be exemplified in the case of the Mauretania.

While a water rate of 13 lb., including auxiliaries, is, I believe, very low for direct-connected turbines, a rate well under 12 lb. should easily be attained with the geared turbine. Therefore I think it would be more just to place the saving in the boiler-room of all three ships between 10 and 15 per cent. per shaft horse-power. This would make the total of saving in the boiler-rooms of Ships I. and II. from 23 to 28 per cent. I believe it would also be possible to improve very considerably on the propellers specified for Ship III.

Engine-Room Weights.—Again, taking the replacement of reciprocating engines first, those specified by Messrs. McLaren and Welsh vary from low piston speed to high—that is, from 500 to 875 ft. per minute.

In six of the eight ships given they credit a saving of weight by substituting geared turbines. The greatest saving for the engine-room and tunnel is 37.3 per cent. for a ship of 13,560 tons displacement and 10,900 indicated horse-power, driven at 18 knots by twin-screw quadruple-expansion engines with 57 in. stroke, running at 82 revolutions per minute (779 ft. piston speed) *

In two examples they credit an increase of weight. The greatest increase is in the case of the 10-knot ship referred to above. It was driven by

* This is the shaft horse-power for the geared turbine. The reciprocating engine has 6250 shaft horse-power and 7250 indicated horse-power. The difference is due to a large drop in propeller efficiency when the gear is fitted, the propeller revolutions per minute having been increased from 87 to 125. By raising the power constant of their gear from 2.08 to 3.5 or 4, the revolutions per minute of the propeller would have been much reduced from 125 with the same size of gear-wheel. By adopting double reduction, the large gear and the weight of the whole installation would have been reduced, the turbine efficiency increased, and the propeller kept at 87 revolutions per minute. Leaving out the increase of turbine efficiency, the reduced shaft horse-power, from 6850 to 6250, would alone have raised the 17.8 per cent. saving to about 25 per cent.

* The geared turbines give 10,550 shaft horse-power, or nearly as much as the indicated horse-power of the reciprocating engines. The reason, again, is that in changing to geared turbines the propeller revolutions were raised from 82 to 125 per minute. As in the previous footnote, the propeller efficiency could have been kept up and the percentage of efficiency raised.

a triple-expansion engine of 30 in. stroke and 500 ft. piston speed. Thus the piston speed was low, and, as the propeller was retained and its revolutions remained unchanged at 100, the whole addition must have been between the slow-running engines and the geared turbines. The weight is increased from 55 to 70 tons, giving an addition of 27.3 per cent. This ship, as stated above, had 560 shaft horse-power. I have not exactly parallel data, but I will give a carefully worked-out estimate for the larger 10-knot ship previously mentioned, which shows a large saving. As this ship is larger than the former, it is relatively slower, and it should be more difficult to show a saving. This example also exhibits the great advantage of double—over single—reduction for slow ships. The propeller revolutions per minute were retained at 85.

	Tons.
Reciprocating engines, 2500 horse-power	114
Geared turbines, single reduction, 1700 to 85 revolutions per minute... ...	78
Geared turbines, double reduction, 3600 to 85 revolutions per minute	54

Taking the rest of the engine-room weights as unchanged, we have a saving by single reduction of 41 tons, and by double reduction of 60 tons. The weights per horse-power are :—

$$\text{Single reduction, } \frac{73 \times 2240}{2500} = 65.4 \text{ lb.}$$

$$\text{Double reduction, } \frac{54 \times 2240}{2500} = 48.4 \text{ lb.}$$

Under the *Interpretation of the Power Constant* I have shown that if the peripheral speeds are kept constant, which they should be approximately, the gears (and, it can be shown, the turbines also) of the small ship will be lighter per horse-power. But the increase of weight in the smaller ship of 15 tons credited to the geared turbines gives :—

$$\frac{15 \times 2240}{560} = 60 \text{ lb. per horse-power.}$$

That is, the *added* weight is considerably greater than the whole weight of the geared turbines need be. The power constant in Messrs. McLaren and Welsh's gear is 1.46, and their turbines run at 3000 revolutions per minute (300 ft. per second mean peripheral velocity of low-pressure exhaust-blades), and these low values may well account for the result at which they arrive, but it would be changed to a valuable reduction of weight by raising both constants The comparison of these two ships is a very striking example of the effect of raising the power constant and peripheral speed in greatly broadening the field of application of the marine geared turbine.

Change to geared turbines leads them in the case of a yacht to an increase of engine-room and tunnel weights of 14.5 per cent. I need not discuss it fully, but here also a higher power constant and peripheral speed would change this to a considerable saving of weight, and in all the other cases they cite the saving would be increased.

In one example this would have avoided the necessity of spreading the gear centres to accommodate the high-pressure and low-pressure turbines (see H, Table of Gear Data and Note, page 492 *ante*). Also, in at least one ship besides those of 10 and 16 knots, referred to above, it would have been found advantageous to adopt double reduction.

Thus from very low-speed vessels to high speed and from comparatively small to very large, the reciprocating engine may be replaced by the geared turbine with an important diminution in the dead weight to be carried, and, as we have seen, in the economy.

The ship with combination machinery has four shafts. The inner shafts are driven by reciprocating engines, and the wing shafts by low-pressure turbines. It is of 35,500 tons displacement and 21 knots speed. With the geared turbines the shaft horse-power is 33,000, and fully 1000 less for the combination machinery. Combined turbines and reciprocating engines, while increasing efficiency over direct-connected turbines or reciprocating engines, must always make a very heavy installation in the engine-room, and it is not surprising that in this case the engine-room and tunnel weights are reduced from 2600 to 1450 tons, a saving of 1150 tons, or 44.2 per cent. This is 3.24 per cent. of the whole displacement, and, if utilised to decrease displacement, should effect a decrease in the fuel bill of over 2 per cent.; indeed, if the decrease of displacement results in a finer model, the saving may be considerably greater.

The last class with which we have to deal is that of the ships changed from direct-connected turbines to geared turbines, the data for which I have reproduced in the table of Ship and Machinery Data. This table shows one great source of saving in weight of machinery and fuel in the decreased horse-power. It arises from the geared turbine so reducing the speed of the propeller that, instead of one which is too small both in diameter and pitch ratio, and which runs at too high a speed, a propeller of the best proportions in all respects, and consequently of maximum efficiency, can be fitted.

With Messrs. McLaren and Welsh's engine-room and tunnel weights for these ships I entirely disagree. I believe the claim has long ago been given up that there was much, if any, saving of weight by substituting direct-connected turbines for reciprocating engines. Yet in one twin-screw ship with quadruple-expansion engines at 779 ft. per minute piston speed and 10,900 indicated horse-power total, the engine-room and tunnel weight is given by them as 1020 tons, while for the quadruple-screw Ship I., of 24,500 shaft horse-power, it is given as only 1070 tons. Again, in a twin-screw ship fitted with triple-expansion engines of 7250 indicated horse-power and 740 ft. piston speed these weights are 550 tons, while for Ship II., of 9850 shaft horse-power, they total 280 tons. While in this case, I think, the estimate of 550 tons could have been considerably reduced, the comparison would still be left incredible It is not possible to adopt other than very low peripheral speed in ships with direct-connected turbines. For instance, the low-pressure rotor of the Mauretania is 140 in. in diameter, and the longest blades are 22 in.* This gives a mean diameter of 162 in. To attain a speed of 26.31 knots, I understand that the revolutions per minute of one of the low-pressure rotors was 195, which gives a mean peripheral speed of 138 ft. per second, and this is considerably above her speed in service. This very low value causes the turbines to be of great length. The over-all length of each high-pressure, low-pressure, and astern rotor, including bearings, is :—

	ft.	in.
High-pressure	45	8
Low-pressure	48	1¾
Astern	30	1¾

The Mauretania's turbines were of the limiting diameter that could have been got into her beam of 88 ft., and at the specified revolutions per minute of propeller, 290, in Ship I., of 73.5 ft. beam, it would not be possible to adopt a diameter which would greatly increase this peripheral velocity; the limit would be 160 to 170 ft. per second. Therefore her turbines would also be very long. Very slight calculation seems to show that her turbines alone, not including the condensers, shafting, propellers, auxiliaries, floors, and other weights, which comprise a considerable percentage of the engine-room and tunnel weights, would well exceed the total weight specified. As strong issue could be taken with the 280 tons specified for direct-connected turbines in Ship II.

While waiting for the experimental gear to be tried, I examined very carefully the case of the Mauretania, and the result is given in ENGINEERING, vol. lxxxviii., page 379, and Fig. 2.† It is there shown that instead of the present very crowded engine-rooms, substituting geared turbines would have allowed of a much better and more open arrangement of machinery, more perfectly divided into water-tight compartments, in one-half of the length. The arrangement is much simpler, in part due to substituting three screws for four. Had I adopted two pinions per gear-wheel, as probably would now be done, the engine-room might have been longer, but not heavier. In the estimate, I made what I then considered an extreme supposition of 6000 horse-power for the experimental gear at 1500 revolutions per minute of pinion, or a power constant of 1.458. This I have fully shown could be more than doubled with further reduction in the weight and space. I am fully convinced that the reduction of engine-room and tunnel weights would be in the neighbourhood of 50 per cent.

In Ship I. the propeller revolutions per minute is cut down from 290 to 125, and in Ship II. from 500 to 280, giving the decrease of shaft horse-power entered in the table of Ship and Machinery Data.

To sum up: By replacement of the direct-connected turbine, the propeller efficiency is increased, decreasing the required power; the engine efficiency is increased, decreasing the steam and fuel consumption further, thus saving weight both in engine and boiler-rooms and bunkers; and there is large saving in weight per horse-power in the engines. The total effect will be such that a smaller and finer ship can be built to perform the same service, giving a still further reduction in weight and power, and therefore in first cost, running expense, and upkeep. The amounts would differ much for different conditions, but the conclusion seems quite assured that a large and necessarily fast direct-connected turbine passenger-ship could not compete with one fitted with geared turbines. In a warship the saving of weight allows of much more powerful offensive and defensive armour and increased radius of action.

* See ENGINEERING, vol. lxxxiv., page 637.

† In making the shaded drawings, the artist represented the rectangles by which I had shown the over-all length and diameter of the direct-connected turbines, as cylinders, thus unintentionally giving an unfair impression of the massiveness of the turbines.

THE INSTITUTION OF GAS ENGINEERS.—Mr. A. E. Broadberry, engineer and manager to the Tottenham District Light, Heat and Power Company, has been elected President of the Institution of Gas Engineers in succession to Mr. John Young, of Hull.

MINERAL RESOURCES OF GREAT BRITAIN.—The Board of Agriculture and Fisheries desire to give notice of the publication of volume 5 of the Special Reports which have been prepared by the Director of the Geological Survey in response to numerous inquiries that have arisen through the conditions brought about by the war. Volumes 1, 2, 3 and 4 are already published, and the fifth of the series deals with the occurrences of certain felspars and the possible extraction of potash from them on a commercial scale. It also describes the workings, past and present, for alum, plumbago, molybdenite, chromite, talc and diatomite. Copies, price 1s., may be obtained through any bookseller from Messrs. T. Fisher Unwin, Limited, 1, Adelphi Terrace, London, W.C., or from the Director-General, Ordnance Survey Office, Southampton.

AUSTRALIAN IRRIGATION.—The Burrinjuck Dam on the Murrumbidgee, in New South Wales, and the storages on the Upper Goulburn, in Victoria, are the only works at present in operation for regulating the flow of the Murray. A preliminary investigation has been made of the Darling, which shows that the most suitable site for the storage of large volumes of water for irrigation purposes is in the lake system to the East, comprising Lake Boolabooka, Ratcatcher's Lake and Victoria Lake, and a number of other lakes fed from the river in high floods from Talywalka Creek, which takes off from the river about 260 miles above Menindie. A large area of high-class land has been commanded from this storage, and the area will be served by the Condobolin Hill Railway, which, however, is not yet completed. The construction of a storage reservoir at Wyangala, below the confluence of the Abercrombie, has been investigated, with the intention of affording water in the river channel for pastoral purposes and for the irrigation of small areas along the river bank by pumping. In view, however, of the unsatisfactory state of the run-off from this catchment, it is unlikely that the scheme will be further considered at present. An alternative proposal is being investigated for an increase of the storage in Lake Cudgellia, which is fed from the Lachlan, and for the pumping thence of water for the irrigation of an area adjacent to the lake. The construction of a storage reservoir has been proposed on this river at Burrendong, below the confluence of the Cudgegong, for the purpose of affording water by gravitation for the irrigation of certain lands west of Nanromine. A smaller scheme, which has received consideration, is the construction of a storage dam on the Campbell at Bathurst. The run-off from this catchment is too uncertain to permit of the construction of any large irrigation scheme, but perennial supplies can be made available for the use of individual irrigators by the construction of storage works on this river, and also on the Namoi, the Peel, the Gwydir and the Mc'Intyre. A scheme has been prepared for supplementing the water supply of the Hunter River district, and providing water for irrigation, by means of pumping on the area adjacent to the Hunter, which is one of the most fertile districts in the Commonwealth, and is capable of carrying a dense population under intensive culture by irrigation. An alternative proposal has been investigated for the construction of a storage dam, either on the Upper Hunter or the Goulburn.

SKIN FRICTION RESISTANCE OF SHIPS.

*Skin Friction Resistance of Ships, and Our Useful Knowledge of the Subject.**

By G. S. BAKER, R.C.N.C. (retired), Member.

§ 1. IN two of the papers published by the William Froude National Tank, reference has been made to, and details given of, experiments and calculations relative to different phases of skin friction resistance. Admiral Taylor and Mr. McEntee have also recently published details of some experiments made in America with friction-boards. The object of this paper is to bring together the useful existing data on the subject of skin friction, both of models and ships, and so to bring out those points on which our knowledge is weak and doubtful. The term "skin friction resistance" is here used to cover all resistance due to the passage of the ship through open water, if the waves set up by the ship are assumed to require no supply of energy, and there are no abrupt or other features in the form to cause the general flow around the ship to break down in any way. The subject-matter has been confined generally to such experiments or data as have a direct bearing on the friction of ships, and reference has been made to experiments on the flow of fluids in pipes or other confined channels only where such experiments serve to explain some phenomena or fill a gap in our knowledge. The subject may be divided into two distinct and separate parts—viz., the friction of a smooth surface, and the friction of a surface which may have any degree of roughness. This term "roughness" will be left undefined for reasons that will appear later, it being used here merely to denote something which is not smooth. Taking first the case of the smooth surface.

ACTUAL EXPERIMENTAL DATA FOR SMOOTH SURFACES.

§ 2. This is practically confined to experiments with flat boards. The oldest and, from its extensive character, the most useful set of experiments is that of W. Froude. Herr Geber and Tideman have also made plank experiments in water, the limits of their work being as given in Table I., and a number of tests have been made at the Froude National Tank.

TABLE I.—*Limits of Data re Friction of Smooth Planks.*

Experiments by	Length of Plank.		Limits of Speed.	
	Maximum.	Minimum.	Maximum.	Minimum.
	Ft.	Ft.	Ft. per min.	Ft. per min.
W. Froude	50	1	650 for long one 940 for short one	100
Herr Geber	21.4	1.97	885	120
Tideman	19.7	1.97	—	—
Froude National Tank	16	3	546 for long one 1153 for short one	100
Beaufoy	21.2	9	600	180

Although these experiments have been made in somewhat different ways, excluding the results with very short planks, there is a reasonable agreement between them where they overlap each other. W. Froude's and the National Tank results are indistinguishable from each other. Tideman's and Geber's fall some 4 per cent. above and below these respectively. W. Froude, in publishing his experimental data, expressed the results in the form $R = f A V^n$; R being the resistance in lbs., A the wetted area in square feet, V the velocity in feet per second, f and n being "constants" varying with dimensions and determined by experiments. Geber and Tideman followed Froude's lead in this matter. The author in a recent paper† has reduced these results, so that all the experiment spots for different lengths of plank plot together on a single curve.

§ 3. When one examines the results for the short planks large variations show themselves, not only between the work of different experimenters, but between different planks tried by the same individual. Thus the value of n found by W. Froude for 2-ft. planks of paraffin and tinfoil—both substances being practically smooth and indistinguishable to the touch in the dark—are 1.95 and 2.16, yet the 20-ft. planks with these two surfaces had nearly the same n value and the same resistance. The author has suggested in the paper quoted that these discrepancies are due to a breakdown or change in the flow of the water past the plank, and by careful experiments with two short planks has shown the general character of the change which takes place. It has been known for many years that the flow of fluid in a pipe changes more or less suddenly, with a consequent change in the law of resistance, when the product (speed of flow) (diameter of pipe) reaches a certain figure. There is apparently the same change in the flow around a plank moving through the water. This change renders the experimental results on short planks of little use in formulating any law of resistance for use with long planks, and is mentioned here merely that one may set aside such results without being accused of ignoring what is not agreeable. But if one must set aside the results with short planks owing to their erratic results, or to their law of resistance differing from that of longer planks, it suggests that ship-model results at low V L values are liable to err, and in any case their skin friction resistance will be uncertain. The minimum limit for V L for reasonably good results is 40, or a speed of 240 ft. per minute for a 10-ft. model. This is the extent of our experimental knowledge of the resistance of smooth surfaces.

SOLID SURFACES.

§ 4. There are no similar extensive data for solid surfaces. Tideman published a table for calculating the resistance of ships which purported to be based on such experiments. The author has not been able to obtain a copy of Tideman's original publication, but believes that neither his actual experimental results nor his method of passing from model to ship were given. Some results for a few forms at low speeds on the surface were published in a paper* by Mr. Kent and the author three years ago. These are given in Table II., together

TABLE II.

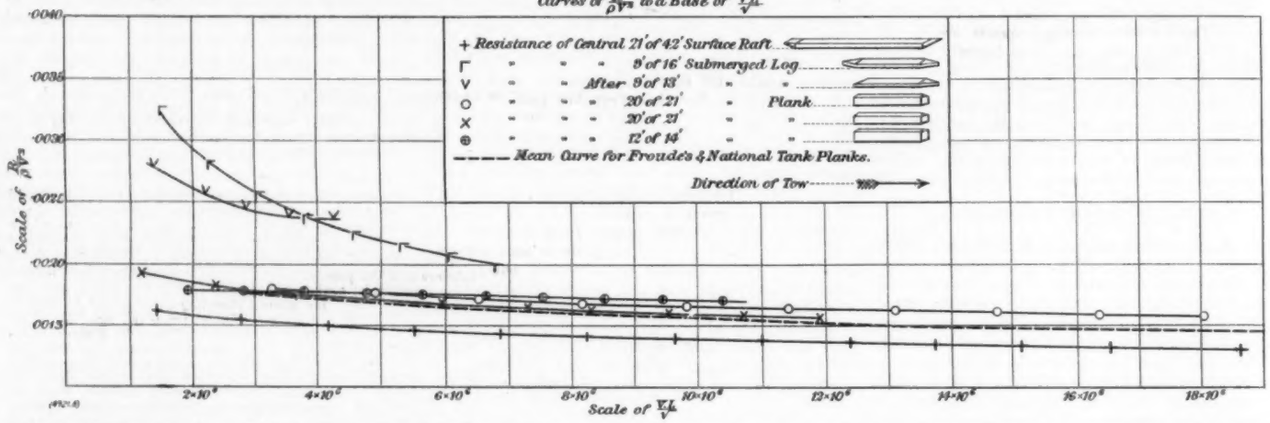
Values of the Ratio $\frac{\text{Measured Resistance.}}{\text{Calculated Skin Friction Resistance}}$ *For a Number of Smooth Models at Low Speeds.*

Type of Model.	Length, Feet.	Prismatic Coefficient.	Actual R. Calculated skin R.	Remarks.
1	2	3	4	5
Mercantile steamer ..	16.0	0.60	1.1	—
T.B. destroyer ..	14.4	0.64	1.05	—
Battleship	14.4	0.63	1.1	—
Greyhound	10.8	0.68	1.1	—
Mercantile steamer ..	16.0	0.68	1.11	—
" " ..	15.9	0.69	1.14	—
" " ..	16.0	0.70	1.19	—
" " ..	16.0	0.76	1.17	—
" " ..	15.0	0.81	1.23	Some eddy-making present.
" " ..	16.0	0.83	1.29	" "

with the similar figures obtained from various other models. The figures given in column 4 are the ratios of the actual resistance at low speeds to the calculated resistance of smooth planks of the same area and length. These results show that the fulness of the form affected the result to a certain extent, all of the models having resistances in excess of those for planks of the same wetted area. Since the publication of that paper a considerable number of other models varying in length from 13 ft. to 20 ft. have been tested in the National Tank, and these have all shown resistances at low speeds exceeding those for planks of the same area and condition of surface by 5 per cent. to 15 per cent. It is possible that some of this excess is due to divergent wave-making, but it is difficult to believe that this would amount to 10 or 20 per cent. of the whole. Tests with several mercantile steamer models in water have shown at very low speeds the same resistance going astern as when going-ahead; and if serious divergent waves were being formed, the much larger angle of entrance of the stern (when used as a bow) should cause a perceptible increase in the resistance. Moreover, the skin friction resistance, estimated from the results of a 3-ft. model tested in a current of air, was slightly *higher* than that obtained from the tests of a 16-ft. model in water. As there were no waves in the case of the model in air, one is led to the conclusion that there could have been none of any importance with the latter, as otherwise its resistance would have been greater and not less than that deduced from the air model. These percentages are necessarily obtained at low speeds, and, although they cannot be regarded as exact, they may at any rate be regarded as indicative of the effect of form on frictional resistance.

Beaufoy tested several forms having the same entrance, run, and cross-section with varying lengths of middle body. These forms were all submerged to a depth of 6 ft. If the difference in resistance of these forms be assumed to be solely due to the skin friction of the parallel body introduced, this skin friction is considerably in excess of that of a plane board. One cannot be at all confident that this assumption is correct, but two of the best of these have been analysed, and the result is shown in Fig. 1 (above),* together with the mean curve for W. Froude's and the National Tank planks.

Fig. 1. SKIN FRICTION RESISTANCE OF SHIPS AND OUR USEFUL KNOWLEDGE OF THE SUBJECT.



THE EXTENSION OF EXPERIMENTAL DATA FOR SHIP CALCULATIONS.

§ 5. The method in use at the present time owes its origin to Mr. W. Froude, and is based upon the hypothesis that the immersed skin of the ship is equivalent in resistance to that of a rectangular plane surface of equal area and length (in line of motion). The law of resistance for these long plane surfaces is assumed to be of the form :—

$$R = f A V^{1\cdot825}, \text{ or } R = f A V^{1\cdot83},$$

f being calculated from the results of the 50-ft. smooth plank by assuming that for any length L over 50 ft. the mean value of f for the whole surfaces is given by

$$\frac{50\left(\text{value of } f \text{ for } 50\text{-ft. plank}\right) + (L - 50)\left(\text{estimated value of } f \text{ for last foot of 50-ft. plank}\right)}{L}$$

The figures given in some text-books differ from those obtained in this way from Froude's planks, partly because of Mr. R. E. Froude's "O" constants published in 1888,† or because of weight being given to Tideman's or other experimental results, but the departure is never

* Paper read before the Institution of Naval Architects, April 12, 1916.

† Trans. North-East Coast Inst., vol. xxxii.

* Trans. Inst. N.A., vol. lv., part ii.; ENGINEERING, vol. xcvi., page 132.

* The results for two submerged planks and a surface raft of Beaufoy are also shown on this diagram as a matter of interest. These are taken from *Nautical Experiments*, Vol. I. The 3-in. planks for which the data are given had very blunt ends, the total angle of entrance being 60°, and the resistances of the parallel portions of the planks were obtained by running short and long planks having the same ends and taking the difference. The result, if regarded as the skin friction of the stated length of plank, is open to some error, owing to the method adopted for eliminating the resistance due to the blunt ends, and to the very small ratio this corrected force bears to the whole resistance of the gear towed. The wetted surface being central in the case of the raft, its resistance is naturally lower than that of a surface meeting still water at its fore end.

† Trans. I.N.A., vol. xxix., page 304.

very serious, and is only in detail and not in method.

§ 6. There are three assumptions made in this procedure :—

(1) that the resistances of a solid body and a plank of the same wetted area and length are sensibly the same; (2) that the resistance of long planks at high speeds can be calculated from the short plank results by the method given; (3) that the quality of the ship's surface is the same as that of the smooth planks.

W. Froude was himself aware that this was merely a means to an end, and Sir William White, in his Manual, states that "it has been suggested that this generalisation requires further and more extended experimental verification before it can be accepted absolutely, especially for ships of great length."

It will be seen from § 4 that, although assumption (1) is sufficiently exact for fine and relatively long models, the body of the form has some effect as the prismatic coefficient increases. This conclusion is supported by the fact that, if the theoretical stream velocities around any solid form are obtained by calculation, it will be found that the mean value of the rubbing velocity of the streams and the form generally exceeds the velocity of the form itself, the excess varying with the fulness. This statement is made as the result of calculations with two-dimensional flow generally, but it has also been found to apply to the surface streams of a light cruiser at wave-making speeds. A three-dimensional case has been worked out by Mr. Kent, and the form and velocity curve are given in Fig. 2 (below). This shows that the square of the rubbing velocity is 1.06 times the square of the stream velocity, the prismatic coefficient being 0.53. That this excess velocity is obtained in practice with all models is demonstrated by the fact that these models when in motion through the water sink bodily in space, and this sinkage is known to be realised in the ship. The passage of the water past the ship involves some velocity and pressure variation of all the stream lines in its locality. When the velocity of the particles of water is high, energy considerations require either a fall in space or a drop in pressure. At the free surface the pressure cannot change, and the water therefore changes level; but under the form some drop in pressure may be realised. Whichever form the change takes, any increase in stream velocity must tend to cause the ship to fall in space, in order to receive the same water support as before. To illustrate this point, a typical curve of vertical movement of the centre of length of a destroyer model is given in Fig. 3 (above). It will be seen that there is a tendency to rise when the speed has risen above that corresponding to $\frac{V}{\sqrt{L}} = 1.5$ (i.e., when the hollow of the entrance wave is working along the stern of the vessel), but even at a speed corresponding to 50 knots for a 300 ft. ship the model is below its still-water position.

§ 7. With regard to assumption (2), the author in a recent paper suggested another method of estimating the resistances of long surfaces from the shorter plank results. This method is based upon the law of dynamic similarity, of which some account was given to this Institution by Dr. Stanton in 1912, vol. liv.* The estimates of skin friction for ships made in this way are generally less than those obtained in the older way. This difference increases as length is increased and becomes important for lengths above about 250 ft. Thus for a 600-ft. ship of ordinary form at 20 knots the estimated power would be 10,300 by the old method and 9000 by the new method, without any allowance for the roughness due to the plate butts, &c. It is not possible without experiments on a large scale to say which of these two methods is correct. Such an experiment was made on the Greyhound, but unfortunately the experiment does not help us on this point. The vessel was comparatively short, being only 172.5 ft. in length, and for such a length, at the experiment speeds, both methods of calculation would give practically the same frictional resistance. The actual resistance of the Greyhound exceeded that estimated by Mr. Froude by some 20 per cent. (taken on the whole resistance), and whether this discrepancy was due to roughness of bottom, as suggested by Mr. Froude, or some other cause, it is too great to enable one to use the result as a check upon skin-friction data.

§ 8. Passing now to assumption (3)—*i.e.*, that the resisting quality of the ship's surface is the same as that of smooth planks—there can be little doubt that for all models all reasonably hard, smooth surfaces give the same result. W. Froude tested several ship compositions on planks and found this to be the case. Fig. 4 (below) gives the experimental spots for a 16-ft. model of 0.66 prismatic coefficient tested with four different surfaces, varnish, paraffin, fine red lead, blacklead, worked into the shellac, and these spots all plot on one curve. The tests made in the Washington Tank with 20-ft. plates 2 ft. deep showed practically the same resistance for shellac varnish and blacklead (the blacklead was laid on over the shellac and not worked into its surface when it was just drying, as at the National Tank). Provided, therefore, that a ship had a wetted surface similar to that of an ordinary smooth model, this assumption would be perfectly correct. In a ship, however, the surface is always broken up by the heads of the rivets, and generally by the landings and butts of the plating. These must have some effect, and must cause any estimate based on the assumption of a smooth surface to be in error on the small side. This is dealt with in detail in §§ 9 (c) and 10. It would appear from these considerations that the present method of extension of experimental data for short planks and bodies, although fairly accurate for short vessels of fine form, is subject to several errors when used for long ships. One of these—that due to assumption (2)—always tends to give an excess estimate for resistance, and the others—due to assumptions (1) and (3)—cause the estimate to be low.

Fig. 2.

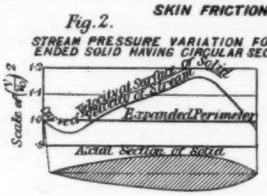

STREAM PRESSURE VARIATION FOR SHARP-ENDED SOLID HAVING CIRCULAR SECTIONS
Original Surface
Expanded Perimeter
Axial Section at Stern

Fig. 3. CURVE OF VERTICAL MOVEMENT OF CENTRE OF LENGTH OF A DESTROYER MODEL. LENGTH OF MODEL 16 FEET

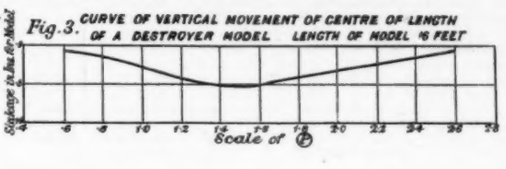
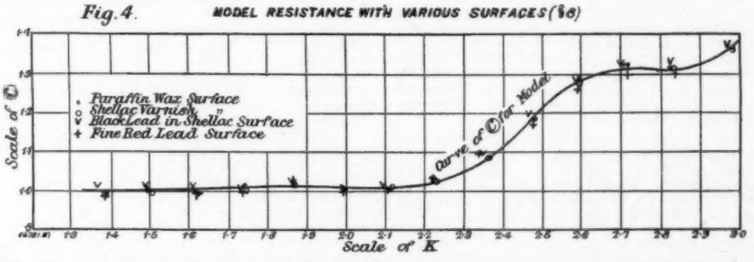


Fig. 4. MODEL RESISTANCE WITH VARIOUS SURFACES (§ 8)



THE FRICTION OF A ROUGH SURFACE.

§ 9. The data upon this have been increased very considerably in the last few years. Most of these data are derived from model experiments, but in some cases authentic data for ships are available. These data are given below in the order of the percentage effect produced by the particular roughness considered.

(*a*) One model of fine form, 16 ft. in length, tested in the National Tank, showed that plate edges increased the frictional resistance 3.7 per cent. The plates on the model represented 4-ft. strakes of $\frac{1}{8}$-in. plating on a 400-ft. ship.

(*b*) A 20-ft. by 2-ft. plate, tested in the Washington Tank, "painted with light lubricating oil," at first showed an increase of resistance about 5 per cent. over that of a varnish surface, but as the oil washed off the resistance excess decreased.

TABLE III.—*Effect of Lapped Butts and Landings.*

Model.	Prismatic Coefficients.	Percentage Increase in Frictional Resistance over Smooth Surface.	
		With Laps and Butts over Whole Length.	With no Laps over the First $\frac{1}{3}$ of Length.
1	0.63	10.3	—
155 B	0.82	8 low speeds 12 highest useful speed.	—
155 C	0.82	—	4.8 at low speeds. 7.2 at highest useful speed.

(*c*) Two models tested in the National Tank with plate edges and lapped butts (the laps of the plates being towards the stern) increased the resistance as shown in Table III. Model No. 1 was the fine form used for test (*a*) above, model No. 155 was full and broad, having 50 per cent. of parallel body in its length (total length 15.3 ft.). The plates on the model represented 4-ft. strakes of $\frac{1}{8}$-in. plating of 20 ft. length for a 400-ft. ship. It will be noticed that the effect of the removal of these laps and butts from the bow in the case of the full model was to reduce the resistance 3.2 per cent. to 4.8 per cent. The variation in percentage effect with these landings and butts as speed is varied is probably due to the angular flow of the streams in the bow as wave-making shows itself. At the top speed there would be decidedly more flow across the plate edges than at the low speeds.

(*d*) One model (No. 1) tested in the National Tank with a very slight amount of fine grit mixed into a good smooth paint showed an increase in frictional resistance of 7 to 13 per cent.

(*e*) If the whole of the discrepancy between the actual resistance obtained with the Greyhound and that estimated by Mr. Froude be attributed wholly to roughness of the copper bottom, the increase in frictional resistance due to it amounts to 27 per cent.

(*f*) A large vessel lying at Newcastle for three months without docking showed an increase in its *total* resistance of 20 per cent., this being the result of measured-mile trials before and after the time-interval given.

(*g*) A 16-ft. by 2-ft. plate tested in the Washington Tank at speeds of 6 to 8.5 knots, with a surface coated with heavy cylinder oil, showed a resistance 48 per cent. higher than that for a smooth surface. But the results indicated that at about 3 knots the resistance would be the same as for the smooth surface.

(*h*) A plate 20 ft. by 2 ft. tested in the Washington Tank after immersion in Chesapeake Bay for two months (July and August, 1914) showed an increase in resistance over that of a smooth surface of about 50 per cent. The fouling and resistance went on increasing up to the month of December, when the resistance stood at about 220 per cent. increase over that for a smooth surface, and remained at that figure for some months. This suggests that a good time for cleaning and painting the bottom of coasting ships, working at about this latitude, is October and November, as there is little growth in cold water for the next few months. Presumably, there would be a period about May and June when the temperature had reached a point favourable for growth when a new coat of paint would prevent their adhesion to the surface.

(*i*) Tests in the Torquay Tank of planks 19 in. deep, of lengths 2, 8, 20, and 50 ft., covered with calico or fine sand, showed an excess resistance over that of smooth planks of the same length of 70 to 90 per cent. for the 50-ft. lengths, and 100 per cent. for the short lengths.

The same planks with medium or coarse sand had excess resistance of 125 and 175 per cent. respectively for a short plank, 93 and 114 per cent. respectively for a long one. The above examples of effect of rough surface have been limited in the case of full-sized ships to those for which the data have been seen by the author. Many other examples may be found in text-books on resistance.

§ 10. In considering the model results, one important fact has to be borne in mind. It is essential for the correct application to ships of these results on small models that the roughness on the model shall be "similar" to that on the ship. Thus a 3-in. weed growth on a ship should be represented by a growth of about 0.15 in. on the model (the scale being assumed as $\frac{1}{20}$), *not* by the same sized growth. Tests with the latter will inevitably lead to a result largely in excess of the effect of the same fouling on a ship. Thus the coarse sand on the plank in case (*h*) would represent a fair growth of barnacles on a ship, and the calico test in the same example would represent about 1 ft. to 2 ft. weed on a ship. The plate-butts and edges in examples (*a*) and (*b*) were to scale, and their effect would therefore be the same on the ship as in the model.

§ 11. The large increase in the ship resistance is not the only effect of a foul bottom. Large increase in the frictional resistance is bound to increase the wake to more or less the same extent. The result of this is that the screw is working at an unduly high slip, with a consequent drop in its efficiency, and this loss is additional to that due to the mere increase in resistance. The examples given show that there is every reason for believing that a ship experiences a large increase in its resistance when the wetted surface is roughened in any way, and, giving due weight to the statements in the previous paragraph, this increase will be about the same in the ship and in the model when both have "similar" rough surfaces.

AMERICAN SHIPBUILDING.—There were 368 vessels, of an aggregate burthen of 1,029,014 tons, under contract to be built or building in private American shipyards at the commencement of May. Of these vessels 221 are designed for salt water and 147 for fresh-water navigation. At the commencement of April the new tonnage building was 1,067,856 tons; and at the commencement of March 945,798 tons. The number of vessels contracted for in April was 137; the Chester Shipbuilding Company is to build three, the Newport News Shipbuilding and Dry Dock Company two, and the American Shipbuilding Company two.

NORTH-AMERICAN MINERALS.—It is stated with regard to the antimony and silver ores of the Wheaton district, Yukon Territory, Alaska, that hand sorting will furnish limited quantities of ore for shipment, but that for any considerable tonnage concentration will be necessary. At Carbon Hill there are natural facilities for erecting a mill, and a wagon road has been constructed to the nearest railway, a distance of 30 miles, with a downgrade all the way. At the hydromagnesite deposits in the Atlin district of Northern British Columbia an estimated quantity of 180,000 tons occurs in surface beds 1 ft. to 5 ft. thick, with no overburden; and it is thought that about 150,000 tons of material, analysing 41 to 42 per cent., can be produced by simple means.

* On "The Law of Comparison for Surface Friction and Eddy-Making Resistance in Fluids." See ENGINEERING, vol. xciii., pages 428, 437.

THE GERMAN NITROGEN INDUSTRY.

WE are indebted to the Sulphate of Ammonia Association, of 84, Horseferry-road, S.W., for the following translation of a very interesting extract from the *Frankfurter Handelsblatt* of the 29th ult. They add that they cannot vouch for the accuracy of the estimates presented, and that one or two of the statements are obviously exaggerated. Nevertheless, the increase in production of nitrogen in Germany is likely to prove larger than hitherto expected :—

The German Nitrogen Industry and the Future of German Agriculture.

"During the last 10 years German agriculture has succeeded in increasing the yield of the land to an extraordinary extent, and in this connection a comparison with France is of interest. Thirty years ago the yield per hectare in France was about the same as in Germany. Since then the yield in France has risen about one-tenth, whereas Germany has nearly doubled her yield, as the following table shows :—

Wheat Yield per Acre in 100 Kilos.

	Yearly Average. 1881–86.	1911–13.
Germany...	12.8	22.3
France	12.0	13.6
Russia	?	6.9

This excellent result is due to the development partly of the farmers' associations, of agricultural schools, and the employment of modern methods, but chiefly to the ever-increasing quantities of fertilisers used. The following is a comparison of the amounts of fertilisers used per hectare during the last few years :—

	Potash.	Nitrate of Soda.
Germany	12.05 kg.	8.10 kg.
France	0.806 „	4.10 „

"Germany has always been well provided with potash, but up to about 10 years ago had to rely almost entirely on imports of nitrate of soda for her nitrogen. The following table shows the increase in the imports of nitrate, and in this connection it should be mentioned that about 10 to 15 per cent. of these quantities have been used for industrial purposes :—

German Consumption of Nitrate of Soda.

1880.	1885.	1890.	1901.	1910.	1911.	1912.	1913.
Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
55,000	155,000	330,000	517,000	723,000	703,000	785,000	747,000
Value (Million Pounds).							
?	1¼	9½	4¼	6¼	6½	8⅛	8¼

"Gradually, however, the German chemical industry has been building up a substitute for nitrate in the form of sulphate of ammonia. At the beginning of this century the production in Germany was still small, and imports amounted to about 48,000 tons per annum. Since 1906, however, things have changed, and Germany has exported larger quantities than she has imported. The development of our consumption of sulphate of ammonia is shown by the following table :—

German Consumption of Sulphate of Ammonia.

Year.	Imports.	Exports.	Excess of Imports Over Exports.	Excess of Exports Over Imports.	Production from Coke Ovens, &c.	Total Consumption.
1888	35,000	—	35,000	—	?	—
1900	23,000	2,000	21,000	—	104,000	125,000
1909	58,000	59,000	—	1,000	281,000	280,000
1910	31,000	93,000	—	62,000	313,000	251,000
1911	24,000	74,000	—	50,000	418,000	368,000
1913	35,000	76,000	—	41,000	501,000	460,000

"The increase in the use of sulphate of ammonia has therefore been extraordinarily rapid. In the year 1913, 460,000 tons of ammonia were used as against 750,000 tons of nitrate of soda. Taking the manurial value of sulphate compared with nitrate as 4 to 3, the 460,000 tons are equal to 610,000 tons of nitrate, so that the two competitors were running each other pretty close already in 1913.

"In 1914, synthetic sulphate of ammonia first entered the lists as a competitor of nitrate of soda on a practical scale. Theoretically, the possibility of producing ammonia by purely chemical means had long been known, and the well-known Norwegian method was first of all developed, the German chemical trade being largely interested.

"The difficulties of introducing this process into Germany on account of the lack of water-power forced the Badische Aniline and Soda works to develop a process of their own. In conjunction with Professor Haber, they proceeded to do this, putting all their energy into the Haber process, and giving up their Norwegian interests. At the beginning of the war the Badische were producing on a scale large enough for one single works, but yet not sufficiently large to compensate for the loss of nitrate of soda. In the first year of the war there was accordingly a considerable shortage of fertilisers for agricultural purposes. But our chemical industry quickly came to the rescue, and should the blockade of Germany be prolonged, we should soon be in a position to deliver more nitrogen for agricultural purposes than agriculture consumed in peace times.

"The following particulars give an idea of the extraordinary rapidity with which the Haber process has developed. The production rose from 30,000 tons in 1913 to 60,000 tons in 1914, and about the middle of 1915 the output of the original works was about 150,000 tons. From 1916 onwards the production is reckoned at 300,000 tons. It is no secret that the Badische Company has lately begun putting up further large plants in another part of Germany, so that its producing capacity from 1917 onwards will no doubt be considerably in excess over that of 1916. Assuming that the Haber production in the near future will amount to 500,000 tons, this process alone will represent the production of an amount of nitrogen very nearly equal to the amount of nitrate of soda we used to import. In passing, we may mention that such a production at a price of 12l. 10s. per ton would represent an annual turnover of 6¼ million pounds sterling for this one firm. Added to this, however, is the fact that, with State aid, further large quantities of nitrogen have been produced in the form of nitrate of lime, with the help of which our agricultural needs can easily be met. In addition, the whole tendency in the coal industry has been towards increasing the development of by-products. Up to the time when the war broke out about one-fifth of our coal was coked, but to-day the war has forced us to resort to coking to a far greater extent than before, and everything points to the conclusion that in the near future the direct combustion of coal will be recognised as altogether uneconomic and disappear, and its place be taken by by-product processes. This, of course, means increased recovery of ammonia from coal. Assuming that only double the quantity of coal hitherto used is employed for the recovery of ammonia, the increase in the sulphate of ammonia production would amount to 450,000 tons. Basing on the above, we can make the following comparison between 1913 and 1917 :—

German Consumption of Nitrogen, 1913.

	Tons.	Tons Nitrogen.
Sulphate of ammonia ...	460,000 =	92,000
Norwegian nitrate of lime	35,000 =	4,500
Nitrate of lime	30,000 =	6,000
Ammonia—Haber process	20,000 =	4,000
Total ...		106,500
Total ...		106,500
Plus nitrate of soda ...	750,000 =	116,000
Grand total ...		222,500

German Production of Nitrogen, 1917.

	Tons.	Tons Nitrogen.
Sulphate of ammonia ...	700,000 =	140,000
Norwegian nitrate of lime	—	—
Nitrate of lime	400,000 =	80,000
Ammonia—Haber process	500,000 =	100,000
Total		320,000
Nitrate of soda		?

"If these estimates are only approximately correct, our own production will already next year be greater than our consumption before the war, including the amount of nitrate of soda imported. In case of need, therefore, we can do without the importation of nitrate of soda for agricultural purposes altogether. This does not mean, however, that the import of nitrate of soda is either unnecessary or undesirable. Nitrate will remain very much wanted for certain purposes, and agriculture will be glad to make use of it as long as prices remain competitive, especially seeing the amount of German capital invested in the nitrate of soda business. If our home production of nitrogen can be supplemented by nitrate of soda, so much the better, for our experts are agreed that we cannot give our agriculture enough nitrogen. The dire necessity which this war has brought upon us, forcing us to help ourselves in all sorts of ways, has in this respect given us a valuable gift for the future, seeing that the new sources of nitrogen will enable us to increase our agricultural production.

"All sorts of possibilities are involved in this. It would be thoroughly in keeping with the character and the accomplishments of German chemical industry to proceed with the production of combined fertilisers after having successfully solved the problem of synthetic production of ammonia. These manures will perhaps one day drive out the old fertilisers in the same way as synthetic indigo drove out the natural product. It is not impossible that Germany may one day become the great exporter of nitrogenous fertilisers. The most important point, however, is the increase in the productivity of our land. The economy of 9,000,000l. per annum on nitrate of soda imports cannot be compared in importance with the saving in our imports of wheat and foodstuffs which would be effected by means of increased fertilising."

A GERMAN-BALKAN COAL COMPANY.—A company under the style of the Balkan Coal Company, with domicile in Berlin, and a capital of 4,000,000 marks, has just been started. The company's object is to supply Turkey and the Balkan States with fuel, in place of the English coal formerly used. Hitherto the Balkan States and European Turkey have imported about 2,500,000 tons of coal annually from England.

TRADE OF NEW SOUTH WALES.—The oversea imports during February were valued at 2,728,772l., and show an increase of 658,260l., or 31.8 per cent., as compared with the corresponding month of last year. The total for the eight months July to February was 21,886,290l., an increase of 2,565,941l., or 13.3 per cent., in comparison with the figures for 1914–15. The oversea exports during February amounted to 3,146,039l., being an increase of 485,083l., or 18.2 per cent., as compared with the corresponding month of last year. For the eight months July to February the exports amounted to 28,663,900l., being an increase of 10,683,986l., or 59.4 per cent., compared with the same period for 1914–15.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, May 31.

A QUIET week in the steel industry possesses no significance in view of the far oversold condition of the market; this oversold condition represents from 10 to 12 months' work on the books. Since the first of the month orders for war material foot up over half a million tons. The increasing steel capacity does not seem to indicate any decline in price. Since last August the average monthly increase in business in tonnage in the Steel Corporation has ranged from 500,000 to 66,100 tons per month; at the present time that corporation has over 10,000,000 tons under contract, and all of the steel companies have 20,000,000 tons of steel to make. Domestic consumers, on account of high prices, have begun to restrict their buying; while European requirements show no falling off, especially as a larger number of steamships are available and the rate of freight has somewhat declined. Quite a number of electrical furnaces have been established. The new open-hearth plants are producing more steel than ever. Manufacturers of wire products are unable to accept all the business that is crowding in. The shipbuilding industry is greatly hampered for want of steel for future delivery. Since May 1 the builders have contracted for 85,000 tons of marine plates and shapes for delivery this year and are anxious to place still larger orders for delivery next year. Makers of agricultural implements are looking as far ahead as next year, and have induced some manufacturers of steel bars to accept orders for delivery during the first six months. The railroads are liberally ordering locomotives, 111 having been "placed" during the past week, of which 20 are for export to France. A very large number of engines for European delivery are being called for, and locomotive makers expect to book contracts from American roads within a few weeks at the farthest, and probably much sooner, for 300 locomotives. The export of war munitions, explosives, supplies and general merchandise from New York reached during the past week in value 61,095,278 dols.; total exports to date from New York this year, 987,630,898 dols. The general volume of business in the country is increasing under slightly improving traffic conditions.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—There is a further decline in the Hull coal traffic. In May 302,692 tons were despatched from the Yorkshire coalfields to the port, a decrease of 130,000 tons on the corresponding period of last year. The total for the year up to date was 1,333,861 tons, a reduction on the same period of 1915 of 660,000 tons. Of last month's total only 78,922 tons were exported, being an average of about 20,000 tons per week, compared with a weekly average of about 60,000 tons during May of last year. For the five months of the present year the total exported was 435,604 tons, or less than 50 per cent. of the same trade during the corresponding period of last year. These figures are still quite distinct from the coal shipped for Admiralty purposes or for the use of the Allied Governments. Over half the total went to French and Swedish customers, but the French tonnage was a drop of 140,000 tons on last year. The shipments to Sweden were about half of those for 1915, whilst only 22 tons were consigned to Norway as against 14,175 tons last year. The Denaby and Cadeby Main contributed about a tenth of the total tonnage sent to the port.

South Yorkshire Coal Trade.—With the exception of a few small pits, all the collieries in this area worked right throughout the Whitsuntide holiday, and thus fell into line with the request of the Government. In nearly all cases it was reported that the output was well up to the maximum and the consumers were able to get full supplies. The situation was in marked contrast to what prevailed at Easter when the closing down of the pits for a comparatively long holiday placed the dealers and merchants in a difficult position. The local inquiry for steam fuels continues on an enormous scale. Works are securing full deliveries of the large-sized fuel, but they have difficulty in obtaining the necessary quantities of nuts, except under contract account. Gas companies are receiving large consignments under contracts, and are also arranging the final details of the contracts for the forthcoming 12 months' supplies. Slacks are a difficult market, and the house coal section grows busier with the cold weather remaining. Coke is now used in increasing quantities and values have an upward tendency. There is renewed activity in the shipping trade. France and Italy are in the market for a large tonnage, whilst neutrals are negotiating for supplies of best South Yorkshire hards and offer the excellent price of 40s. per ton at pits. Greek ports, however, are ruled out of this department of the coal market. Quotations: Best branch handpicked, 20s. 6d. to 21s. 6d.; Barnsley best silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. 6d. to 16s. 6d.; small nuts, 15s. to 16s.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 12s. to 13s.; seconds, 10s. 6d. to 11s. 6d; smalls, 8s. to 9s.

Iron and Steel.—All the large firms report that they were able to work throughout Whitsuntide with the minimum of dislocation of the "shops," and the output has been a tremendous figure. The time and a half was a big inducement to the workers to attend, but, even allowing for this, the response in every respect was excellent, and would gladden the hearts of the Ministry of Munitions. The export trade of Sheffield increases rapidly, particularly with regard to iron and steel manufactures. The tonnage of steel bars, angles, rods, shapes, sections, &c., is also a considerable advance,

whilst, despite the Government export restrictions on steel blooms, billets, and slabs, the figures for last month show the tonnage was on the upgrade. New departures have been made in the shape of new works and works extensions with a view to capturing German trade in the world's markets. The effort is chiefly directed to the manufacture of scissors, cheap table and pocket knives, razors, hacksaw blades, twist drills, carpenters', plumbers' and engineers' tools generally. Germany had a flourishing trade in these goods in pre-war days, and Sheffield's present bid for it is being attended with considerable success. Several firms are specialising in small types of twist drills, for which there is an enormous demand. Materials are not yet to hand in sufficient quantities to meet all requirements, and the deficiency is most marked. With regard to hematites West Coast brands are marked at 136s. to 140s., with delivery here, and East Coast remain at 128s. 3d.; but the question of price does not give as much concern as the pressing one of supplies. The billet position is easier, though many consumers do not feel prepared to pay the heavy prices American makers are now demanding. If the present rise continues American billets will soon be the equal of the home articles in price, though greatly inferior in quality. More Government contracts have come to Sheffield. Razors, scissors, pincers, pliers, turnscrews, wire-cutters, and shears of different kinds, are wanted in large quantities from one firm alone, whilst other orders include 4000 chisels, 5000 files, 2000 hand-saws, 10,000 garden rakes, and 3500 farriers' and drawing knives. For overseas, the indents are for steel, saws, electro-plate, tools, hardware, springs and vices.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-iron Market.—Meantime, of course, the Glasgow pig-iron warrant market remains closed, and all speculative business is suspended. The stocks of No. 3 iron are being gradually reduced, 2000 tons having been accounted for during the past week.

Scotch Steel Trade.—In the steel trade there is little or no change in the ceaseless activity which pervades every establishment. If any difference be noticeable it is in the direction of a daily-increasing output, and now that the annual fair holidays in the West of Scotland have been postponed to a later date than usual, there is every expectation that the greatest "spurt" ever known will be put on, not only to maintain the immense output, but to add to it in every conceivable way. "Shell bars and more shell bars" is still the cry, and the pressure for delivery is very great. With this continued expansion of work in fulfilment of orders for war material, there is little opportunity for anything extensive in the way of ordinary mercantile business being put through meantime. Export trade also, with the exception of the requirements of the Allied Governments, is very nearly "a closed book," the whole of this business being in the hands of the War Trade Department, who alone can grant licences for shipment. All round Government pressure is very great, and in some quarters it is even suggested that more stringent oversight may yet be required in order to keep the supply of war munitions and materials level with the heavy demand. Prices are steady and firm: Ship plates being quoted 14*l.* and upwards, according to specification; boiler plates, 15*l.*, or even more; and angles, off and on about 14*l.* per ton.

Malleable Iron Trade.—Both steel and iron bars are a heavy business with malleable-iron makers just now, there being no lack of orders, particularly on Government account. Indeed, whether directly or indirectly, Government is at present the largest consumer, although, as there is as yet no embargo on exported malleable-iron, the overseas shipping trade is of quite favourable dimensions, especially for iron bars. The scarcity of raw material and the probable advance in the price of pig-iron after the end of this month are tending to keep up rates, and while "Crown" bars of ordinary quality are still quoted 14*l.* per ton, a further 5s. per ton is being demanded for some of the better grades. None of the smaller sizes or sections are now available for ordinary purposes, these being all required for Government contracts.

Scotch Pig-Iron Trade.—No lack of good business is being done in all grades of pig-iron, hematite especially being in constant demand. Practically the entire production is being absorbed on home consumption, so that, with this and the Government restrictions, very little is available for export purposes, and, in consequence, the shipping trade is rather quiet. The continued demand for hematite is responsible for a certain scarcity of foundry iron, owing to the furnaces having been transferred to the production of hematite instead. Higher levels will very shortly come into force, although meantime the prices of makers' (No. 1) iron remain unchanged.

War Pressure and Holidays.—The proposals made by the Minister of Munitions regarding the postponement of all general holidays until after July has been vigorously taken up in the West of Scotland, and an important pronouncement has now been made. A special meeting of the Glasgow magistrates was held on Monday when the matter was fully discussed, and a satisfactory decision arrived at. In the afternoon also a joint conference of masters and men took place in the offices of the Shipbuilding and Engineering Employers' Federation, 28 trades' unions in the Clyde area being represented. At both meetings the question was very fully gone into, the general feeling being that the best interests of the country would be served by work being strenuously persevered in for the next few weeks without any unnecessary break. As now officially fixed, the Fair Holidays for the Lower Reaches of the Clyde—Greenock and Port Glasgow district—will extend from Wednesday, August 2, till Monday, August 14; Paisley district will remain unchanged, from Thursday, August 10, till Monday, August 21; and in Glasgow and the Upper Reaches, the holidays will commence on Thursday, August 17, continuing till Monday, August 28. A representation will most probably be made to the Ministry of Munitions to sanction the annual Trades' Holiday, which always falls on the last Saturday in August, being amalgamated with the Autumn Holiday in September, thus giving the workers an entirely free week-end before the pressure of the winter's work is resumed.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig continues on only a limited scale, due entirely to the difficulty experienced in obtaining iron. Buyers are keen, and would readily place substantial orders for forward delivery, but makers act with much caution, and are not at all disposed to commit themselves heavily. So far as home trade is concerned, business is passing within the limits prescribed by the Local Committee appointed to regulate distribution. The price of No. 3 for June delivery is fixed at 82s. 6d., but it is quite nominal, no iron being available. Several July–August sales for home consumption are reported at 87s. 6d., and a little has also been sold for September delivery. It is stated that the new maximum of 87s. 6d. will remain in force until the end of September. As regards export trade there appears little prospect indeed of an early resumption of negotiations with neutral countries, and practically all new business with our Allies is subject to official sanction. The export price of No. 3 is 100s. and odd lots are being sold to our Allies at about that figure. Prices of the lower qualities of Cleveland pig are near the same as the quotations for No. 3, and No. 1 is put at 4s. to 5s. higher.

Stocks of Cleveland Pig.—Stocks of Cleveland pig are low. Makers have next to none at their yards, and most of the iron in the public stores is earmarked for disposal. The quantity held in the public warrant stores here now stands at 31,349 tons, composed of 29,585 tons of No. 3 quality, and 1762 tons of other descriptions of iron, deliverable as standard. Since the beginning of the month the stock has been reduced by 1869 tons, 2105 tons of No. 3 having been withdrawn and 236 tons of standard iron having been added.

Hematite Iron.—The scarcity of East Coast hematite pig is felt even more acutely than is that of Cleveland kinds. Under the conditions prevailing producers opine that deliveries are fairly adequately maintained, but many home consumers are pressing urgently for larger supplies, and there are reports that Sheffield customers are protesting against the quantities going to Scotland whilst demands nearer home are not satisfied. No new export business, even with our Allies, is possible just now, but deliveries to France on running contracts are maintained so far as is possible. Large supplies are due to that country. The promised increase of output by the blowing in of more furnaces has not yet been fulfilled, but hope is entertained that additional furnaces will be blowing before the end of the month. Nos. 1, 2, and 3 remain at 122s. 6d. for home consumption, and 140s. for export.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough are certainly below what could be wished, but considering the embargo on exports, they may be regarded as satisfactory.

Coke.—The quantity of coke available for distribution is hardly adequate to needs, and the make will certainly have to be increased if local consumption is enlarged. Had sufficient coke been forthcoming, the number of blastfurnaces blowing would already have been added to. The maximum prices are unaltered, average blast-furnace kinds standing at 28s. at the ovens, and qualities low in phosphorus, 30s. 6d. at the ovens.

Foreign Ore.—Excellent supplies of foreign ore are steadily coming to hand on running contracts, and consumers must now be well placed. The high prices demanded by some sellers have not been obtained, and no difficulty would now be experienced in purchasing Rubio of 50 per cent. quality at 36s. ex-ship Tees. Sellers are prepared to accept that figure on the basis of a 17s. freight Bilbao-Middlesbrough, the price at which controlled consumers are privileged to arrange for steamers through the Government. The freight in the open market, however, is 19s. So far this month imports of foreign ore to the Tees amount to 98,721 tons.

Manufactured Iron and Steel.—The rather numerous ordinary commercial inquiries in the market for finished iron and steel attract very little notice, attention of manufacturers being still fully absorbed on Government work. Common iron bars are 13*l.* 15s.; best bars, 14*l.* 2s. 6d.; double best bars, 14*l.* 10s.; treble best bars, 14*l.* 17s. 6d.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 15s.; iron ship-rivets (¾ in. diam.), 17*l.*; iron ship-rivets (⅝ in. diam.), 18*l.*; iron and steel packing iron (parallel), 10*l.*; iron and steel packing iron (tapered), 12*l.* 10s.; steel bars (no best), 14*l.* 10s.; steel ship-plates, 11*l.* 10s.; steel ship-angles, 11*l.* 2s. 6d.; steel sheets (singles), 18*l.* 10s.; steel sheets (doubles), 19*l.* 15s.; steel strip, 17*l.*; steel hoops, 17*l.* 10s.; steel joists, 11*l.* 2s. 6d.; and heavy steel rails, 10*l.* 17s. 6d.

NOTES FROM THE SOUTH-WEST.

Cardiff.—New business is still checked in Welsh steam coal. Tonnage has not been arriving so freely, and, at the same time, buyers for the French market have shown some disposition to pursue a waiting policy, the committee recently appointed to make arrangements for shipments under the new limitation of prices scheme having made but slow progress. The authorities have further held up exports to neutral countries by refusing licences, so that the market open to colliery owners and exporters has become limited. Among other conditions which have affected current business, we should mention the fact that the authorities have continued to take very heavy quantities of coal and that holiday influences have also been at work. House coal, patent fuel, and coke have been scarce and strong. The best Admiralty large coal has been, to some extent, nominal; secondary qualities have made 50s. to 52s.; Monmouthshire black veins, 50s. to 51s.; ordinary Western Valleys, 49s. to 50s; Eastern Valleys, 45s. to 47s. 6d.; best bunker smalls, 29s. to 30s.; and cargo smalls, 20s. to 23s. per ton. In bituminous coal, best households have made 23s. to 24s. at the pits; No. 3 Rhondda large, 50s. to 52s.; smalls, 33s. to 35s.; No. 2 Rhondda large, 39s. to 40s.; and No. 2 smalls, 24s. to 25s. per ton. The latest quotation for patent fuel has been 50s. to 52s. per ton. Special foundry coke for export has realised 62s. to 65s.; good foundry coke, 60s. to 62s. 6d.; and furnace coke, 50s. to 55s. per ton.

Welsh Coal for France.—A meeting was held at Cardiff on Friday last of representatives appointed by the colliery owners, coal exporters and shipowners, trading with France, to form a committee to control exports under the Government limitation of prices scheme. It was decided to appoint Mr. T. E. Watson, President of the Cardiff Chamber of Commerce, as chairman, with three vice-chairmen, Mr. T. J. Callaghan, Mr. J. T. Duncan, and a gentleman to be nominated by the coalowners; Mr. W. H. Mewton was subsequently selected. The question of the forms to be issued with respect to supplies of coal and tonnage and other matters were referred to a sub-committee made up of the chairman and the three vice-chairmen.

Western Trade Matters.—The Branksome Chine Steamship Company, Limited, has declared an interim dividend of 15 per cent. for the half-year ending June 1.—A similar dividend has been announced by the Canford Chine Steamship Company, Limited; in each case the dividends will be paid free of income tax. Graham's Navigation Merthyr Collieries, Limited, has decided to split its ordinary capital of 30,000*l.* in 6000 5*l.* shares into 30,000 1*l.* shares; the company has also decided to create 2000 6 per cent. preference shares of 1*l.* each, to be distributed as a bonus of two preference shares to holders of five 1*l.* ordinary shares.—The Welsh coal owners pay under protest the 15 per cent. conceded in wages by Sir G. Askwith, intervening on behalf of the Board of Trade; it is contended, however, that the course taken by Sir G. Askwith was irregular, and an arbitrary act on the part of the Board of Trade, taken under pressure from the workmen's representatives.—For the 12 months ended March 31 William Cory and Son, Limited, realised a profit of 453,136*l.*, increased to 511,366*l.* by a substantial reliquat brought forward from 1913–14; a dividend and bonus amounting together to 15 per cent. are proposed for the year upon the ordinary shares, a balance of 188,969*l.* being carried forward; the reserve funds are also increased to 500,000*l.* The profits of 1915–16 (453,136*l.*) compare with 215,328*l.* in 1914–15, 313,906*l.* in 1913–14, 213,524*l.* in 1912–13, and 178,660*l.* in 1911–12.—At the last meeting of the Cardiff Chamber of Commerce the President said the coal owners had had a hint that if the Government experienced much difficulty in dealing with the bunker coal question they would take the South Wales collieries and "run" them themselves. The coal-owners must clearly do their best to help the country and its Allies in their hour of need.—The directors of the Gwann-cae-Gurmey Colliery Company, Limited, recommend an interim dividend for 1915–16 at the rate of 5 per cent. per annum.—Mr. W. H. Mewton, a leading coal-owner, has been elected chairman of Locket's Merthyr Collieries (1904), Limited.—A report presented to the Swansea Harbour Trust states the tin-plate trade increased in May to the extent of 13,000 tons, principally to France (on account of the war) and to Japan. The executive committee recommended that free storage of tin plates should be discontinued and that 30s. per ton per week should be charged in future after the first 24 hours.—The Conciliation Board for South Wales has been considering the question of workmen's attendance at the coal pits with a view to an increase in current production. At a meeting held on the subject at Cardiff on Friday, the workmen's representatives intimated their readiness to co-operate with the coal owners to secure a better attendance of men during the war.—Mr. C. A. G. Pullin, secretary of the Consolidated Cambrian, Limited, and three of the companies forming the Cambrian Combine, will retire from that position at the close of June; he has been invited to join the boards of the Cambrian and Glamorgan Collieries; he has been a director of the Britannic and Naval Company since it joined the combine. Mr. V. D. Hailey becomes secretary of the Consolidated Cambrian and the Glamorgan Steam Coal Company, Limited.

METALLIC PERMANENT WAY.—In consequence of the war, a continued decline is observable in our exports of permanent-way material, which amounted in May to only 619 tons, as compared with 1578 tons in May, 1915, and 11,239 tons in May, 1914; while in the five months ended May 31 the shipments fell to 4965 tons, as compared with 23,333 tons in the first five months of 1915, and 48,313 tons in the first five months of 1914.

LIFT-LOCKS AT KIRKFIELD, ON THE TRENT CANAL, ONTARIO, CANADA.

DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY, LIMITED, ENGINEERS, MONTREAL, CANADA.

(*For Description, see Page* 569.)

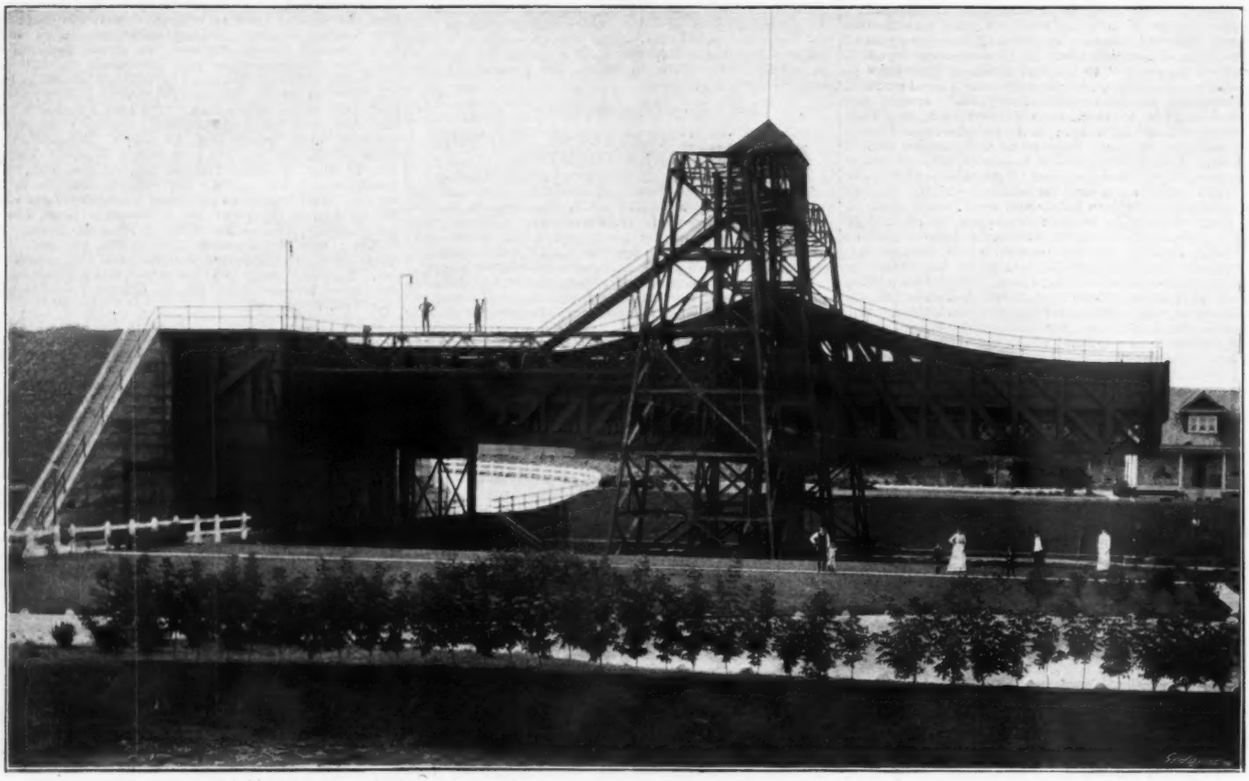


FIG. 44.

THE ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

THE Standing Committee on Engineering appointed by the Advisory Council for Scientific and Industrial Research held its first meeting on Wednesday, June 7. The Committee has been so constituted as to represent both the scientific and industrial sides of engineering, and includes the following members nominated by the professional associations :—

Institution of Civil Engineers : Sir Maurice Fitzmaurice, C.M.G.

Institution of Electrical Engineers : Mr. J. S. Highfield.

Institution of Mechanical Engineers : Dr. Dugald Clerk, F.R.S.

Institution of Naval Architects : Sir Archibald Denny, Bart.

North-East Coast Institution of Engineers and Shipbuilders : Mr. Herbert Rowell.

Manchester Association of Engineers : Mr. Alfred Saxon.

Institution of Engineers and Shipbuilders in Scotland : Mr. James Brown.

The following members were appointed directly by the Advisory Council :—Mr. F. R. Davenport ; Mr. Alfred Herbert ; Professor Bertram Hopkinson, F.R.S. ; Mr. C. H. Merz ; Mr. V. L. Raven ; Mr. A. A. Remington ; Mr. G. Gerald Stoney, F.R.S. ; Mr. Douglas Vickers ; Professor Miles Walker. The Advisory Council have appointed Sir Maurice Fitzmaurice, C.M.G., to be chairman.

The committee was welcomed by Sir William M'Cormick, Chairman of the Advisory Council, and Dr. H. F. Heath, Administrative Secretary of the Council. Sir A. Selby-Bigge, Secretary to the Committee of the Privy Council for Scientific and Industrial Research, also attended, and emphasised the importance attached by the Government to the need for greatly increased activity in research in connection with industry. In Sir Maurice Fitzmaurice's opening statement, as Chairman of the Standing Committee, several important aspects of the Government scheme as issued in July, 1915, were referred to, and attention was directed in particular to the necessity for securing that British industries shall get as large a share as possible of the full value of the results of any successful researches, and shall retain at least the initial advantages derived from them. He felt in this connection that the committee would be in a position to advise the Government organisation for research as to the means of securing that their operations should yield the maximum benefits to the trade and industry of the Empire. Applications for aid must be dealt with on as broad lines as possible, without red tape, and with a constant regard to the ultimate object of the Government scheme, which is to help the industrial community of the Empire in the contest with the common trade enemy. It would be of great value that applicants for assistance to researches should make it clear at the outset whether results, if obtained, should be considered as of a confidential nature, as in arranging our experimental work we must avoid conditions calculated to help foreign competitors. Much time and money had been spent upon research in the works of individual firms whose aggregate expenditure for the purpose far exceeded the sums at the disposal of the Committee of Council, and from the industrial side such work by firms appealed to him as the most hopeful arrangement. But the Government had made a decided step forward by showing their interest in industrial research, and though he expected much more from the scheme, the gain would be great if the only result were the training of research workers. Too much must, however, not be expected from research and experimental work in themselves, for these alone would not win back the industries which should never have left us, or even retain those we still possessed. Though it was not for the Standing Committee to deal with such questions, individual and combined efforts were needed to secure that the products of this country find their way to those who need them at home and abroad, and to see that what is wanted is supplied by our industries. Sir Maurice Fitzmaurice hoped that it would be possible to co-operate with our fellow-countrymen beyond the seas in carrying out many useful investigations.

The formation by the Advisory Council for Scientific and Industrial Research of a Standing Committee on Mining, constituted so as to represent both the scientific and industrial sides, has now been completed. The Standing Committee includes the following members nominated by professional associations :—

Institution of Mining Engineers : Sir William Garforth, Dr. John Haldane, F.R.S., Dr. R. T. Moore, Mr. Wallace Thorneycroft.

Institution of Mining and Metallurgy : Mr. Edward Hooper, Mr. Edgar Taylor.

Iron and Steel Institute : Professor H. Louis.

The South Wales Institute of Engineers : Mr. W. Gascoyne Dalziel.

The following members were appointed directly by the Advisory Council :—Sir Hugh Bell, Bart. ; Mr. Hugh Bramwell ; Lieut.-Colonel W. C. Blackett ; Professor Cadman ; Professor Frecheville ; Mr. Bedford McNeill ; Mr. Hugh F. Marriott ; Sir Boverton Redwood, Bart. ; Mr. C. E. Rhodes. The Advisory Council have appointed Sir William Garforth to be Chairman. The Committee is divided into two sections, as follow :—

Section on the Mining of Iron, Coal and Hydrocarbons.—Sir William Garforth (Chairman) ; Sir Hugh Bell, Bart. ; Mr. Hugh Bramwell ; Lieut.-Colonel W. C. Blackett ; Professor Cadman ; Mr. W. Gascoyne Dalziel ; Dr. John Haldane ; Professor Louis ; Dr. R. T. Moore ; Sir Boverton Redwood, Bart. ; Mr. C. E. Rhodes ; Mr. Wallace Thorneycroft.

Section on the Mining of Minerals other than Iron, Coal and Hydrocarbons.—Mr. Edgar Taylor (Chairman) ; Sir Hugh Bell, Bart. ; Professor Frecheville ; Mr. Edward Hooper ; Professor Louis ; Mr. Bedford McNeill ; Mr. Hugh Marriott.

PERSONAL.—Messrs. J. Dampney and Co., Limited, of Cardiff, inform us that they have just opened a branch office at 30, Sandhill, Newcastle-on-Tyne.

OUR LOCOMOTIVE EXPORTS.—Our exports of locomotives exhibit depression, but they have been rather better maintained than our rail exports. Thus, while rail exports to the Argentine Republic have practically ceased, locomotives were shipped to Argentina to May 31 this year to the value of 128,319*l.*, as compared with 34,740*l.* in the corresponding period of 1915, and 546,805*l.* in the corresponding period of 1914. The aggregate value of our locomotive shipments in all directions in the first five months of this year amounted to 527,389*l.*, as compared with 999,598*l.* and 1,775,392*l.*

AMERICAN GOLD.—The output of gold in the United States during the 10 years ending with 1915 inclusive was as follows :—

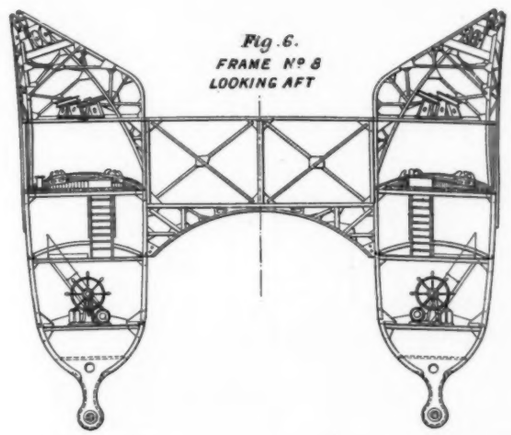
Year.	Output.	Year.	Outp
	Oz.		Oz.
1906	4,565,333	1911	4,687,053
1907	4,374,827	1912	4,520,719
1908	4,574,340	1913	4,299,784
1909	4,821,701	1914	4,572,976
1910	4,657,017	1915	4,783,857

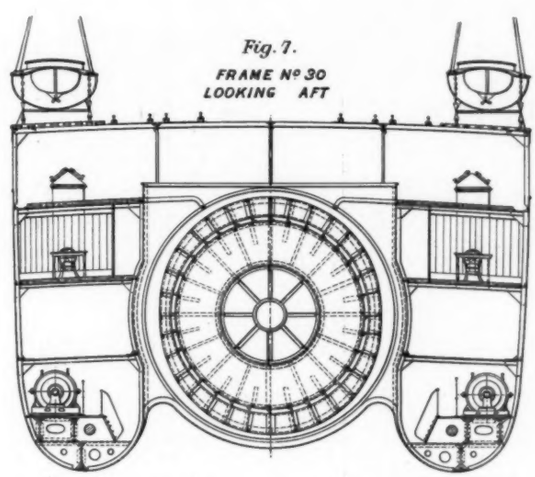
The principal feature of the returns is their remarkable steadiness, although the output increased but slowly during the decade.

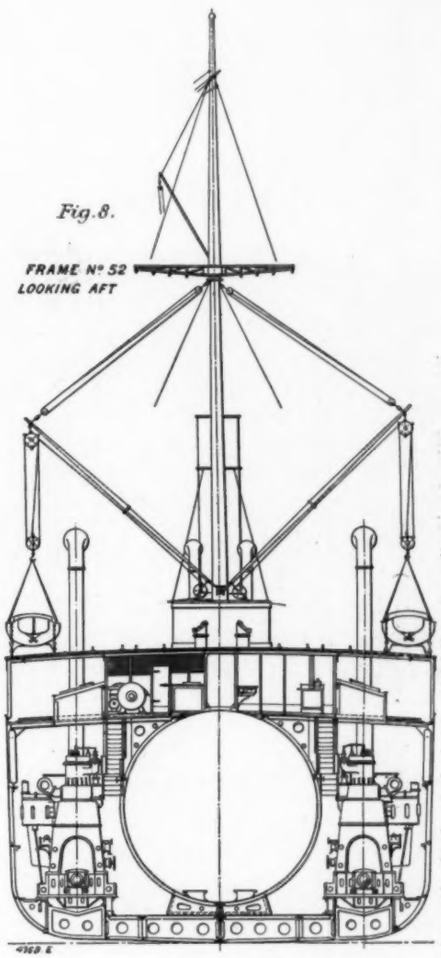
THE BRAZILIAN SUBMARINE DEPÔT MOTOR-SHIP "CEARA."

CONSTRUCTED BY THE FIAT SAN GIORGIO COMPANY, SPEZIA, ITALY.

(*For Description, see Page* 569.)







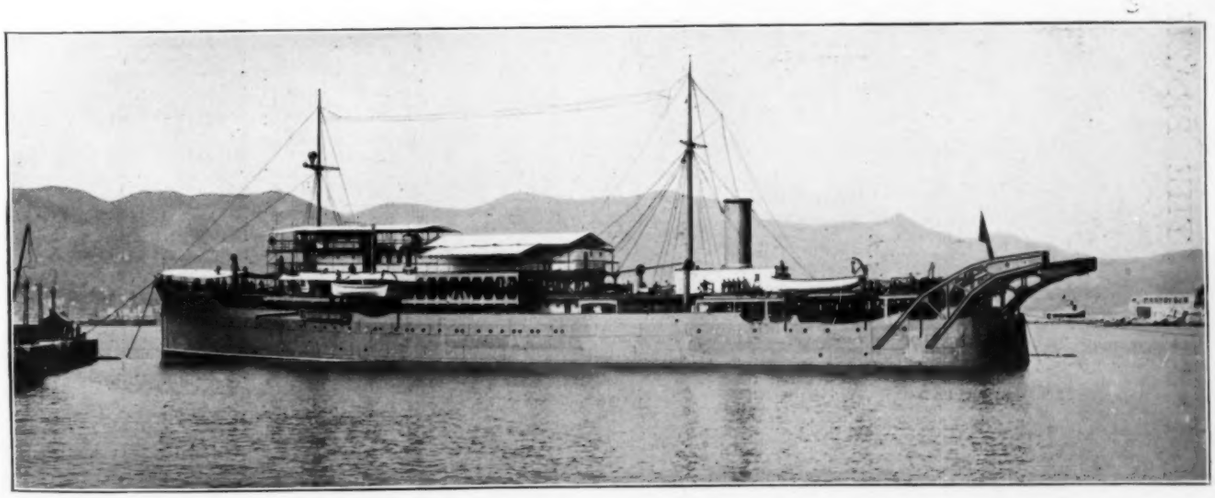


FIG. 9.

(*To face page* 568.)

THE BRAZILIAN SUBMARINE DEPÔT MOTOR-SHIP "CEARA."

CONSTRUCTED BY THE FIAT SAN GIORGIO COMPANY, SPEZIA, ITALY.

(For Description, see Page 569.)

Fig. 1.

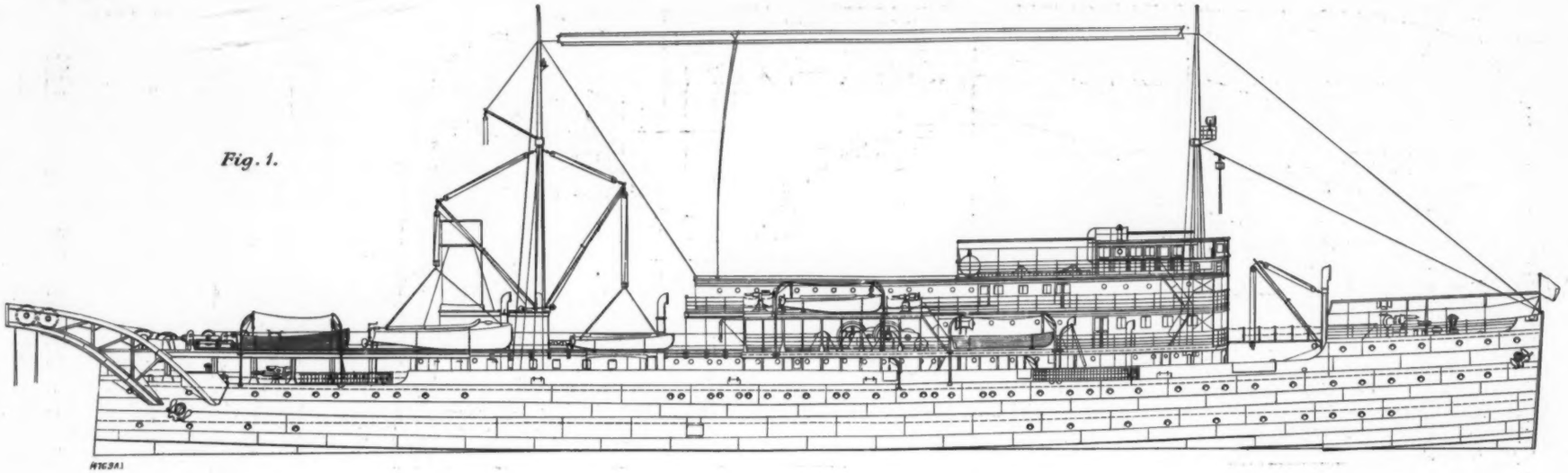


Fig. 2.

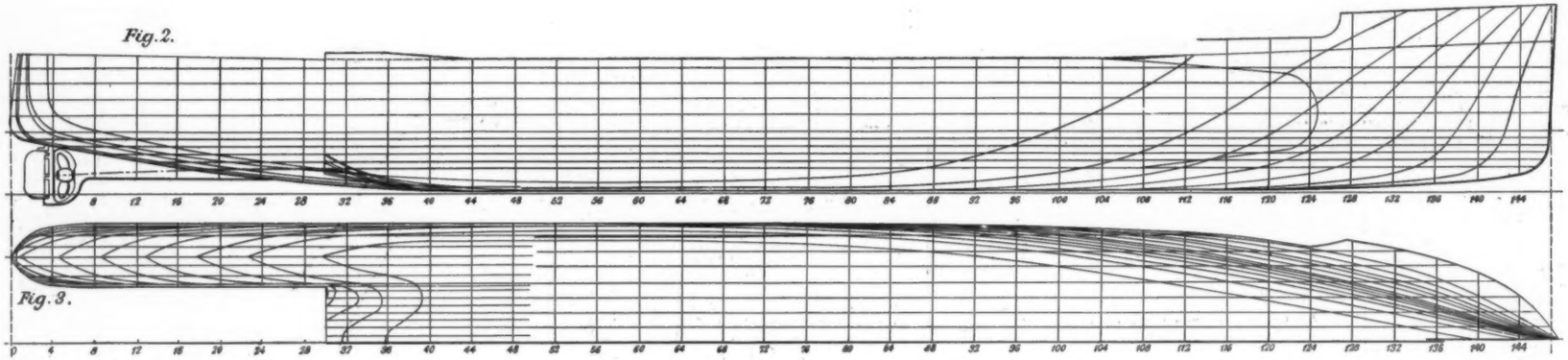
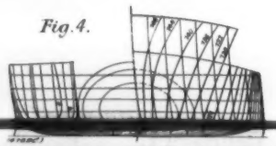


Fig. 3.

Fig. 4.



Main Measurements and Data.

	Metres.
Length between perpendiculars ..	100.000
Breadth at upper deck	15.700
Breadth at water line	15.500
Depth from keel to main deck beam ..	6.200
Depth at fore end of keel	1.400
Diameter at the extreme part forward	5.000
Height of cylinder from keel	1.500
Frame spacing	0.680
Extreme frame spacing forward and aft	0.700

Anchor-Chains and Cables.

	Kg.
No. 2 bower stockless anchors forward ..	3000
No. 2 bower stockless anchors aft ..	2500
No. 1 stream stockless anchor	2100
No. 1 kedge ex-stock anchor	860
No. 1 kedge anchor, no stockless ..	430
300 metres of steel wire from main deck aft after anchors	51
165 metres steel wire for kedge anchors ..	105
165 metres steel wire for mooring, circ. ..	105
Hemp mooring ropes, two in number, 165 metres each, circ.	177

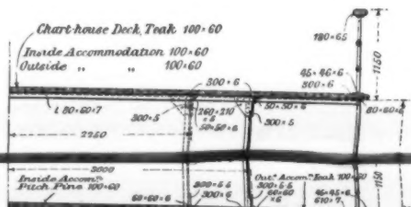


Chart-house Deck, Teak 100×60
Inside Accommodation 100×60
Outside " " 100×60
Inside Accom.ⁿ Pitch Pine 100×60
Oil⁴ Accom.ⁿ Teak 100×60

Length between perpendiculars	100.000
Breadth at upper deck	15.700
Breadth at water line	15.500
Depth from keel to main deck beam	8.300
Draught forward	5.000
Draught aft	5.000
Displacement moulded	7,100
Displacement to outside of shell plating	7,400
Height of cylinder from keel	3.500
Frame spacing	0.680
Extreme frame spacing forward and aft	0.700

No. 2 bower stockless anchors aft	2500
No. 1 stream stockless anchor	2100
No. 1 kedge ex-stock anchor	860
No. 1 kedge anchor, no stockless	430
165 metres steel wire for kedge anchors, after anchors	51
165 metres steel wire for kedge anchors	105
165 metres steel wire for mooring, circ.	105
Hemp mooring ropes, two in number, 165 metres each, circ.	177
Two ropes as on rove, circ.	152

Doubling on Outside and Deck Plating.

Upper deck plating			from frames 52 to 68
"	O Sheerstrake outside plating	"	0 " 42
"	D " "	"	8 " 24
"	E " "	"	21 " 36
"	F " "	"	21 " 38
"	G " "	"	8 " 38
"	M " "	"	24 " 37
"	N " "	"	0 " 38
"	S " "	"	2 " 27

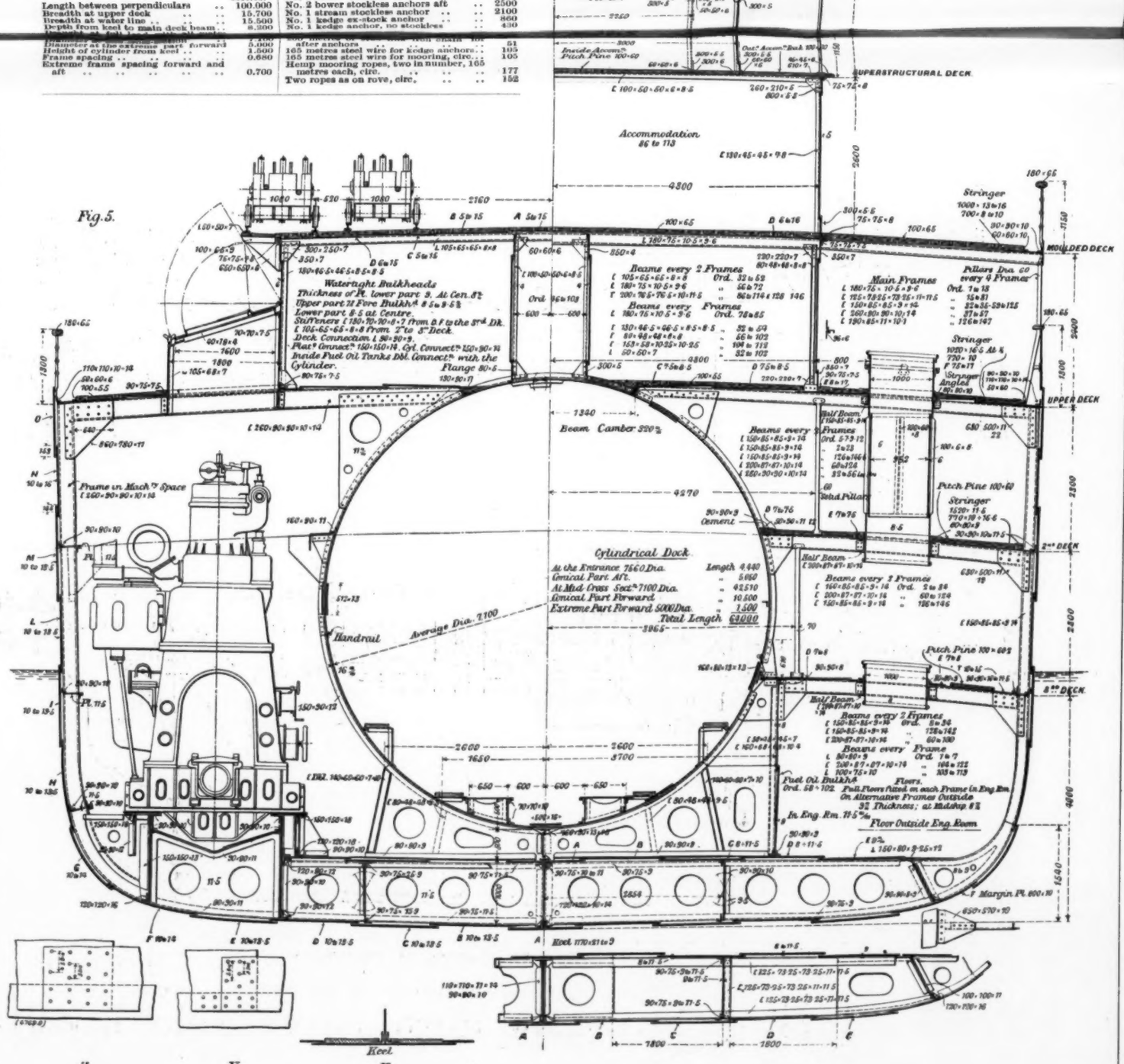
Rivetting.

Items.	Rivets. No. of Rows.	Butt-Strap. Breadth.	Butt-Strap. Thickness.	Lap Butts Ends.	Lap Butts Listing.	Pitch. Plates.	Pitch. Beams.	Rivets. Angle-Bars.	Rivets. Frames.	
Keel.										
Midship	25	Quad.	635 S	26			3.5			ϕ
F. & A.	25	Treble	483	21			3.5			5
Midship										
F. & A.	25	Doub.				153	4.5			
Outside Shell Plating from Strake B to Strake M.										
Midship	22	Treble			225	V fig Y				
F. & A.	19	Doub.			135		4			
Midship	22	Doub.				135	4.5			
F. & A.	19	Doub.				115	4.5			
O. Sheerstrake.										
At centre	25	Quad.			330		V fig. Z V fig Y			
F. & A.	25	Treble			254					
Midship	25	Doub.				153	4.5			
F. & A.	19	Doub.			135	115	4.5			
Upper Deck Stringer.										
Midship	22	Quad.			290		V fig. Z V fig Y			
Midship	22	Treble			225					6
Midship	22	Single				76	4.5			
F. & A.	19	Doub.			135		4			
F. & A.	19	Single				65	4.5			
2 and 3 Deck Stringer.										
All lengths	19	Doub.			135		3.5			6
All lengths	19	Single				65	4.5			4.5
Upper Deck Plating.										
Midship	16	Doub.			111		3.5			
F. & A.	16	Single			70		3.5			6
Midship	16	Single				57	4.5			
F. & A.										
2 and 3 Deck Plating.										
Midship	16	Doub.			111		3.5			
F. & A.	16	Single			70		3.5			6
Midship	16	Single				57	4.5			
F. & A.										
Double Bottom Plating.										
Midship	19	Doub.			135		3.5			
Midship	19	Single				65	4.5			
F. & A.	16	Single			70		3.5			
F. & A.	16	Single				57	4.5			
Margin Plate.										
Midship	19	Doub.	250 S				3.5			
F. & A.										
Midship	19	Doub.				115	4.5			5
F. & A.										
Middle Line Keelson.										
Midship	22	Treble	420 D	9			3.5		3.5	
F. & A.	19	Doub.	250 D	125			3.5		4.5	
	19	Single					4.5			8
	16	Single					4.5			

Frames with outside shell plating 5.5 to 6 ϕ

5.5 ϕ engine-room
7 ϕ remainder

Fig. 5.



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LIFT-LOCKS AT PETERBOROUGH, ON THE TRENT CANAL, ONTARIO, CANADA.

DESIGNED AND CONSTRUCTED BY THE DOMINION BRIDGE COMPANY, LTD., ENGINEERS, MONTREAL, CANADA.

(*For Description, see Page 569.*)

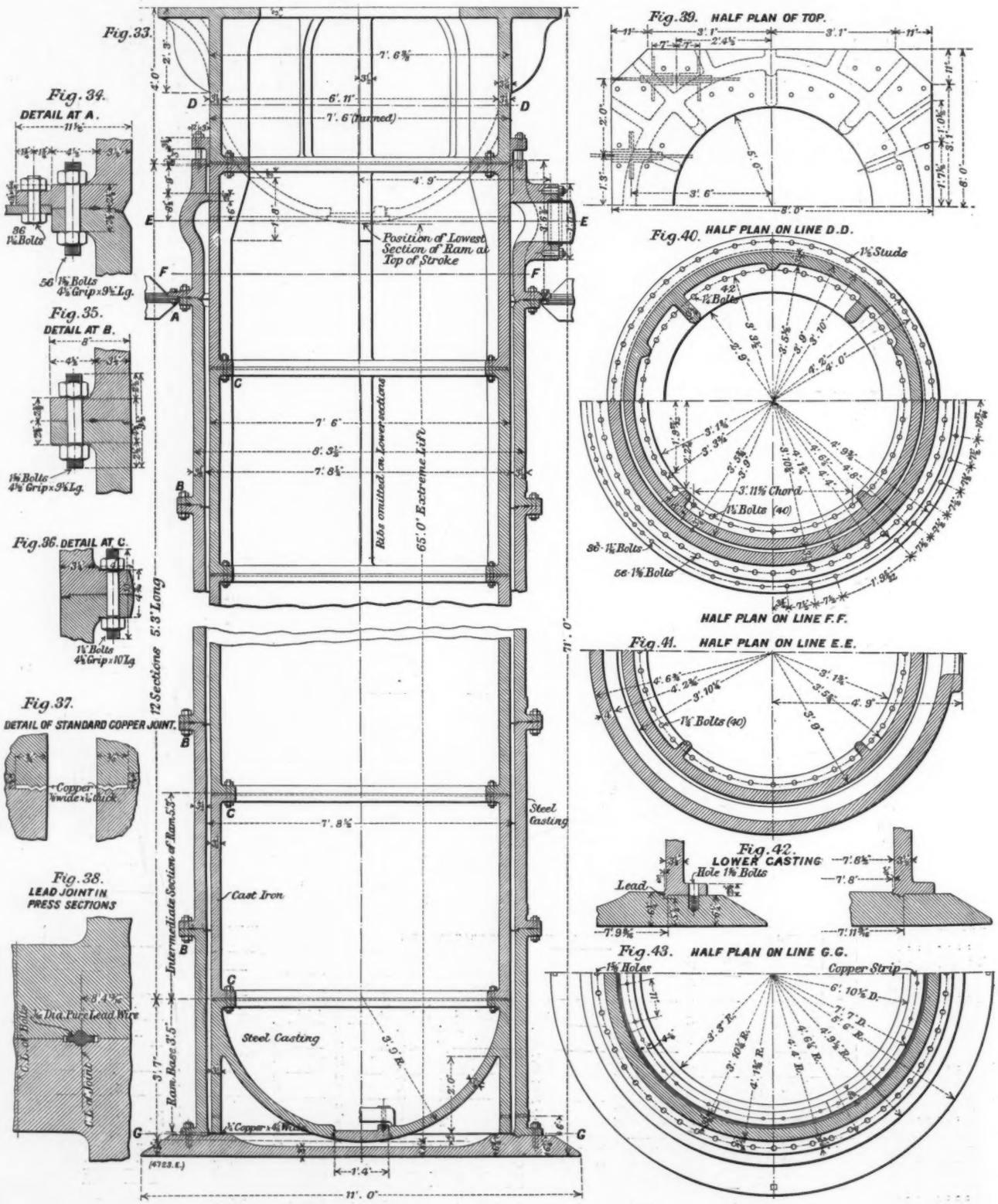
Fig. 33.
Fig. 34. DETAIL AT A.
Fig. 35. DETAIL AT B.
Fig. 36. DETAIL AT C.
Fig. 37. DETAIL OF STANDARD COPPER JOINT.
Fig. 38. LEAD JOINT IN PRESS SECTIONS
12 Sections 5'.8" Long
Intermediate Section of Ram 5'.5"
Ram Base 3'.5"
Position of Lowest Section of Ram at Top of Stroke
Ribs omitted on Lower sections
65'.0" Extreme Lift
71'. 0"
Steel Casting
Cast Iron
11'. 0"
Fig. 39. HALF PLAN OF TOP.
Fig. 40. HALF PLAN ON LINE D.D.
HALF PLAN ON LINE F.F.
Fig. 41. HALF PLAN ON LINE E.E.
Fig. 42. LOWER CASTING
Fig. 43. HALF PLAN ON LINE G.G.

(*To face page 569.*)

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaugnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-968, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8598 GERRARD.

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NOTICES OF MEETINGS.

THE LONDON SOCIETY.—Monday, June 19, at 5 p.m., at the Hall of the Royal Society of Arts, John-street, Adelphi, W.C., under the presidency of the Right Hon. Lord Devonport, P.C. A paper will be read on "The Port of London, Past, Present, and Future," by Mr. Arthur Crow, F.R.I.B.A.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 21, at 4.30 p.m., at 70, Victoria-street, Westminster. Papers to be read: 1. "Report on the Phenological Observations for 1915," by J. E. Clark, B.Sc., and H. B. Adames. 2. "Audibility of the Gun-Firing in Flanders over the South-East of England, September, 1914, to April, 1916," by Miller Christy and William Marriott, F.R.Met.Soc. 3. "The Relation between Atmospheric Pressure and Rainfall at a Single Station," by Lieutenant E. H. Chapman, R.E.

THE INSTITUTION OF WATER ENGINEERS.—Friday, June 23, at 2.30 p.m., at the apartments of the Geological Society of London, Burlington House, W. The Twenty-First Summer General Meeting. The following papers will be read and discussed:—1. "The Alignment Diagram Applied to the Flow of Water in Uniform and Compound Mains," by Mr. D. Halton Thomson, M.A. (Cantab.). 2. "Plans and Records of Water-Distribution Systems," by Mr. William P. Walker, A.M.I. Mech. E.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JUNE 16, 1916.

IMPERIAL AND INTERNATIONAL TRADING CONDITIONS.

THE opening last Wednesday of the Conference in Paris regarding Imperial and international trading conditions, attended by representatives of the home country, our dominions beyond the seas, and allied nations, opens up an avenue of wide possibilities in respect of industry and commerce. If wise counsels prevail there need be no speculation as to the result. To begin with, however, it is essential that we should have a clean slate. We must get rid of all preconceived ideas, however firmly these may seem to have been rooted in economic principles. The shibboleths of the party politician must be erased. We must face the future with a full consciousness of the significance of events of the recent past. The Empire must advance along new lines, based on the survey which has revealed the inequalities that have obstructed our view of legislative and industrial needs, and has disclosed pitfalls for mishaps during the war which, had other measures been adopted years ago, would not have befallen us. The day is past when we can consider academically such questions as Tariff Reform, Protection or Free Trade. Whatever name new measures may fall under, they must have for their fundamental aim the securing of that measure of employment to the workers of the Empire, of that degree of scientific development on the part of employers, and of that extent of commercial expansion by which alone we can counteract the immense drain on our resources during the present war.

At once it should be made clear that although the result must be injurious to our enemies, such cannot be recognised as our dominant or primary aim. We seek to end for ever Prussian military domination, but it is inconsistent with British traditions that we should desire completely to cripple the German Empire. On the other hand, the law of self-preservation is as applicable in times of peace as in war. The Germans themselves have through a long series of years applied this rule, although, with our characteristic complacence, we have failed or refused to recognise the full significance of every step taken in that commercial aggrandisement of our present-day enemies which so greatly assisted them in the prosecution of the war. Never again must any of the natural products which are essential to our manufactures, and are obtainable in our dominions or in the home country, be in the slightest degree under the indirect or direct influence of the commercial propaganda of a possible enemy. It would be easy to show how, even in the maintenance of war supplies, apart altogether from the production of commercial peace manufactures, we found ourselves at the outset of war gravely handicapped because of the stoppage of the supply of necessary materials. This is due in part to the capturing of sources within the Empire, and also to the crippling of home industries by German commercial methods. There has been, and to some slight extent continues to be, a belief that this crippling was the consequence of superior technical qualities—notably in chemistry—on the part of Germany. To this view we have always taken exception. The cause is rather to be found in the failure of those responsible for legislation and administration to recognise that industry can be assisted materially by procedure consistent with true economic principles. It is because the Imperial and international trading conference in Paris may recognise such procedure, and will establish its consistency with sound economic principles, that its immense potentialities are fully recognised.

We have said that the future aim of the politician must be to assist in ensuring the full employment of our workers. There are many ways of accomplishing this most desirable end. The relations between employers and workers must be improved by a recognition on the part of the former that high earnings by the latter are advantageous, provided every worker utilises to the greatest extent, and for the fullest time consistent with physical and mental capacity, the manufacturing appliances provided. So far as this may be inconsistent with the restrictive measures formerly imposed by workers' organisations—and there can be no doubt that these were operative—all restrictions must be removed. That is purely a question of internal arrangement.

For the present, however, we are concerned more with the wider issue, and here there arises the problem of securing such profits as will enable producers to improve their manufacturing plant and processes so as to make the cost of output such as will give a low selling price in association with high earnings for the workers. There is no inconsistency in this policy, but as Britain can produce more than is consumable within the kingdom, it becomes incumbent upon those responsible for Imperial and legislative agreements so to legislate for industry as to nullify the effect of aggressive and unfair competition, not only from without but in Imperial and international markets. It has been enacted that there can be no protection in this country of foreign patents unless measures are taken for the working of those patents here to ensure employment for labour. It is equally important that the doctrine of *laissez-faire* should be further revised, so that foreign nations shall no longer exploit the British market at the expense of the British worker by giving some inhabitants cheap products while crippling industry and increasing unemployment.

The Paris Conference may first be regarded here from the Imperial standpoint. Our Dominions and Colonies have rendered magnificent service to us and to our Allies during the war. The magnificent performance of the Anzacs in Gallipoli, the heroic resistance of the Canadians at the Ypres salient, and other gallant acts of offence and defence during the war entitle our Dominions to be regarded as equals rather than dependants. It follows, therefore, that in any future trade agreements it is the duty of the home country to recognise that they have an equal right of consideration with us. But apart from this, our industrial needs make it indispensable that we should foster to the fullest possible extent not only the recovery of the natural wealth of the Dominions for Imperial use primarily, but stimulate agriculture and the manufactures which are indigenous to the respective countries. Much is possible along those lines, and if financial equilibrium is to be brought about, everything convenient must be done, however much it may upset our preconceived ideas as to tariff arrangements between the nations within the British Empire.

The Conference is concerned also with the international trading relations between the British Empire and our Allies. They have suffered with us, and therefore concerted measures must be taken so that they may recover their full commercial vigour along with us. There is nothing like mutual sorrow for binding close the bonds of friendship. We can conceive, therefore, that in years to come

there will be a common interest and common purpose not only in maintaining that universal peace for which we are striving at great sacrifice, but for the establishment of that prosperity which alone can heal the wound in the body, human and industrial.

The settlement of the details of the International Trading Agreement necessarily involves issues of great delicacy. There must be no interference with the internal affairs of any State. Compromise rather than the enforcement of principles is necessary to success; but one initial step is compulsory on this country before any problem can be tackled, and that is the recognition that trading agreements are necessary. We must also recognise, to begin with, that those principles of the past in which we are at definite disagreement with trading practice in other countries must be departed from in so far as these are inconsistent with the arriving at satisfactory international trade agreements. Principles must be subservient to the claims of expediency, and if the nations for whom we are fighting so that they may live their own lives without interference and develop their own resources without aggrandisement are to continue to work out their destinies, there must be commercial reorganisation as well as military co-operation. The Germans have utilised their trade, as we have already said, in order to strengthen their military position strategically and tactically, not only by acquiring railway concessions and attempting to secure naval bases, but by thinly disguised commercial absorption of rights as to raw materials and similar supplies That must end.

Germany has also tried to weaken national industry by the practice of dumping, than which there are few more insidious processes. To the individual purchaser cheapness commends itself, but we must in future consider the national good rather than the individual advantage. Dumping, even at low selling prices, has materially assisted German industry, and the gain to this country from the low cost of the importation is infinitesimal when compared with the influence that it can achieve from the national point of view. We need only instance the importation of electrical machinery to this country, and to others. There is also the selling of forgings and other similar productions. A British municipal corporation may secure an immediate financial advantage in importing a large electrical generator at the dumping price, but if, as a consequence, there is less employment for the electrical workers within the boundaries of the municipality, or even within the kingdom, and if by idleness and loss of profit there is no stimulus to progress in technics, the natural gain is very problematic. This applies also to forgings. The same principle is operative with all articles that are dumped in this country. The practice, on the other hand, confers advantage in Germany. Full employment in German factories permits larger sums to be spent on experimental research towards developments, which again assist them in competition. They can well afford to sell at low price. Presuming a manufacturer has orders on his books for only 80 per cent. of the producing capacity of his plant, and he chooses to work it at its maximum rate, he can exact full cost of production, adequate profit and full charges against the 80 per cent. for which he has orders, while the remaining 20 per cent., against which no profit and no charges are debited, can be disposed of at the net cost; as a rule rather more is got, because it is sold in competition with goods made in this country, against which are the disadvantages of meeting rates of wage which no one seeks to reduce to the level of those paid in Germany, and in addition full charges—rates, taxes, &c.—and a fair profit.

This is one problem to be faced by the Paris Imperial and international negotiators, and the most gratifying feature is the rapidity with which public opinion in this country is changing towards the overthrow of the closely-cherished principles of *laissez-faire*, and the recognition by the legislator that trade must be supported by the application of new ideas based upon the principle of employment for all. The potentialities in this direction may be summed up in the fact that British imports of manufactured goods from Germany have attained a figure of 167 millions per annum.

REFRACTORY MATERIALS.

REFERENCE has frequently been made during the past 18 months to the fact that for many refractory materials British consumers had become dependent on Germany. It is therefore of interest to note that, for a certain class of refractory materials, neutral testimony is emphatic as to the great superiority of the British article. No doubt much has been effected in Germany by organised scientific research on a large scale, and there is every reason to hope that the investigations now in progress at Professor Bone's laboratory at the Imperial College of Science will go far to make good our deficiencies in such classes of refractory material as we have hitherto had to import. As already mentioned, however, there are certain classes of refractory materials in large demand which Germany has hitherto failed to supply of good quality.

Some interesting data on this head are to be found in a paper recently contributed to the Proceedings of the Manchester District Institution of Gas Engineers by Mr. J. West, M. Inst. C.E. Mr. West quotes a report made by Mr. Irminger, Chief Gas Engineer to the Copenhagen Municipality, on an exhaustive series of tests made to compare the relative resistance of the best British and the best German materials when used for combustion-chamber arches. The German materials failed, whilst the Derbyshire silica bricks kept their original form, merely becoming glazed on the outer surface. As a consequence, the silica blocks and bricks have been adopted throughout for these chambers. The result has been, Mr. Irminger states, that the retorts do not sink, whilst with the best German materials there was a settlement of more than 6 in. Arches of the silica bricks last as long as the retorts (about 1500 days), whilst when the German refractories were used the average life was only 100 days. Mr. Irminger further points out that short-period tests may be most misleading. Thus some of the best German clay retorts do well for months and then, he says, commence to shrink.

Mr. West quotes quite similar testimony from America, where experiments were made by Mr. H. A. Carpenter, at Lowell, and an exhaustive test of combustion-chambers built with English and the best German materials. The former remained true, whilst the German gave way.

As noted, this testimony is gratifying in view of the many and deserved complaints which have been made in regard to the neglect of our manufacturers to supply refractories for other purposes equal to what could be obtained from Germany. An instructive light is, however, thrown on this remissness by Mr. West. He states that when in charge of the Maidstone Gas Undertaking he required for certain purposes a particularly good quality of retort. He gave an order to a maker to supply the very best he could regardless of price. The result was excellent, the quality of the retorts being such that they proved in the long run much the cheapest in spite of their high price. First-quality materials of home manufacture were therefore to be had 40 years ago by those prepared to pay a fair price. A little later he was appointed Chief Engineer to the Manchester Corporation Gas Undertaking. He found that the practice was for the Gas Committee to order so many thousand feet run of retort without definite stipulations as to quality. The result was that the contract was awarded solely on the question of price. There was haggling over an additional penny per ft. run when the payment of an extra shilling per ft. run would not have been a large matter if the full value was put into the retorts. Actually many makers were, he found, refusing to quote for their best goods, so that all makers, good and bad alike, were liable to be reckoned equally incapable of turning out a good retort.

Conditions of this kind are very likely to arise whenever the technical advisers to municipal bodies are not men of strong character, and it is difficult to retain men of this kind in a service where the salary is awarded to the office and not to the individual, being the same whatever the characteristics of the occupant.

Another difficulty which sometimes arises, which is not touched on by Mr. West, is the readiness of certain firms, who have thought fit to economise in the matter of technical assistance, to undertake the same guarantees as their better-equipped competitors. The latter may perhaps have spent many thousand pounds in acquiring the knowledge necessary for the attainment of a certain end. When a firm of the former type succeeds in getting an order, it often expends an amount of ingenuity in trying to evade the contract conditions, or to jockey the results, which, if properly applied, might have gone far towards the achievement of success in a legitimate manner. One unfortunate consequence is that their action may give a bad reputation to all goods of nominally the same character, so that their more able and efficient competitors, who could have fairly met the guarantees, suffer both by direct fire and by ricochét.

In his paper Mr. West explains how it was that he came to take up the manufacture of silica refractories. When higher temperatures began to be used in gas-making, higher fire-resisting properties were demanded both in retorts and settings. These qualities could be provided by the use of silica goods, but trouble arose from the very considerable expansion of this material under heat. Fire-clays, on the other hand, contract. The silica obtained from the Derbyshire pits contains, Mr. West states, about 96 per cent. of silica, so that there was a fair margin for the addition of other materials without destroying the fire-resisting qualities. As the result of exhaustive experiments, Mr. West did at length succeed in producing a brick which, tested by Dr. Mellor, did not change in its dimensions when heated to 1350 deg. Cent. Subsequent experiments have, however, shown that, whilst the expansion was too small for measurement on single bricks, under the conditions of the test, it was appreciable on a long mass of brickwork, a column 8 ft. high expanding $\frac{7}{8}$ in. when heated to 2600 deg. Fahr. This figure is, however, very low for silica bricks in bulk and can, Mr. West states, be easily provided for.

Another important point brought forward by Mr. West is that it is not sufficient to test the refractory properties of a material simply by exposing it in a furnace along with a Seger cone. Certain materials which, tested in this way, are very refractory, will fail at relatively low temperatures if supporting a load.

Some comparative figures due to Dr. Mellor are as follow:—

Kind of Material.	Yield Temperature.	Fusing Temperature.
China clay ...	Cone 14.	Cone 35.
	1410 deg. Cent.	1710 deg. Cent.
	2570 deg. Fahr.	3218 deg. Fahr.
Best fire-clay bricks	Cone 15.	Cone 32.
	1435 deg. Cent.	1710 deg. Cent.
	2615 deg. Fahr.	3110 deg. Fahr.
Silicious brick	Cone 26.	Cone 34.
	1580 deg. Cent.	1750 deg. Cent.
	2876 deg. Fahr.	3182 deg. Fahr.

In another test made by Mr. West a brick carried a load of 84 lb. per square inch whilst maintained at a temperature of 2600 deg. Fahr.

The higher the content of silica the greater the temperature resisted. But it is not always the most refractory material that is best suited to particular applications. Thus, at the Sheffield Gas Works a brick containing about 85 per cent. of silica is found best for retort settings, as the heat resistance is sufficient and the expansion relatively low.

Mr. West gives the following particulars of the four qualities made.

For Steel-Furnace Works.—Bricks and blocks containing from 93 to 95 per cent. of silica. Test for refractoriness, from 1730 deg. to 1770 deg. Cent. = 3146 deg. to 3218 deg. Fahr.

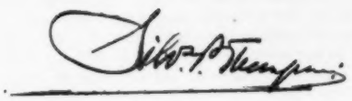
For Gas-Works.—(1) Special for segmental retorts: bricks and shapes containing from 91 to 92½ per cent. of silica. Test for refractoriness, from 1710 deg. to 1750 deg. Cent. = 3110 deg. to 3182 deg. Fahr. (2) "B.B." quality, containing from 89 to 91 per cent. of silica. Test for refractoriness, from 1650 deg. to 1690 deg. Cent. = 3002 deg. to 3074 deg. Fahr. (3) Ordinary bricks, containing 85 to 88 per cent. of silica. Test for refractoriness, from 1610 deg. to 1630 deg. Cent. = 2930 deg. to 2966 deg. Fahr.

In selecting bricks it is important that tests shall be made under standard conditions as otherwise nominally equivalent results may be far from properly comparable.

THE LATE DR. SILVANUS PHILLIPS THOMPSON.

THE announcement of the death of Dr. Silvanus Thompson will be received with deep regret by very many people who know little or nothing of the many physical sciences of which he was so distinguished an exponent. While science—particularly optics and electricity—occupied most of his attention, he had time to spare for many other pursuits, and to whatever he turned he brought not only an acute intellect, but also a genial, happy personality, which rendered him welcome in circles far remote from those in which the scientific man is generally to be found. His knowledge was so extensive and his tastes so catholic that he could establish a common ground of intercourse with men of very various qualities. Among artists he could talk of art and exemplify his remarks by his own clever water-colour sketches of Alpine scenery, some of which had been hung in the Royal Academy. Among bibliophiles he was an authority on first editions; among antiquarians he was known as the author of admirable studies on Gilbert's "De Magnete" and the rare "Epistola" of Peter Peregrinus; in music he was a keen amateur, with a wide knowledge of the subject; among astronomers he could hold his own in discussing the latest discoveries; he was a collector of jewels and rare stones; indeed, there were few subjects interesting to a man of taste and intellect of which he had not more than a superficial acquaintance.

From a Photograph by Elliott and Fry.



Electricity and optics were, however, the two sciences which claimed Dr. Thompson's chief attention. He was appointed Professor of Physics in Bristol University College in 1878, the year when the possibilities of electric lighting were revealed to the world at the Paris Exhibition, and the subject immediately attracted his attention. From that time until his death he occupied an important position in relation to electrical engineering, and thousands of engineers, both here and abroad, have been indebted to him for a clearer knowledge of electrical science than they would otherwise have obtained. He had the capacity of perceiving the essential principles underlying a machine or a process, and of conveying his knowledge to others in simple and lucid language. His book entitled "Elementary Lessons in Electricity and Magnetism" has had a circulation of 100,000 copies in this country, and in addition has been translated into French, German, Italian, Polish and Japanese. Further, his "Dynamo-Electric Machinery" has appeared in French and German, in addition to the eight English editions, while his "Polyphase Electric Currents" has had a wide circulation. Dr. Thompson's Cantor Lectures of 1883 were a revelation to the engineering world as to the construction, theory and mode of working of dynamo-electric machinery. It was about that time that the boom in electric companies set in, and he was constantly consulted by financiers and others as to the value of the machines and processes which were being offered to the public. At all times his assistance was eagerly sought in relation to patent matters, for his powers of lucid description were exceedingly valuable in the witness-box, while his unrivalled knowledge of what had been done or proposed in the past often threw a most unexpected light on the validity of patent claims. His help was also frequently asked by designers when demands were made upon them which went beyond their theoretical knowledge. Recognition of the great services he had rendered to the profession was made by the Institution of Electrical Engineers when they elected him as President in 1899. He had always been an active and zealous member of the Institution, and had served it in many capacities. In looking through the volumes of Proceedings one is struck with the numerous contributions he made to the discussions, and the wide range of subjects on which he spoke well. He only contributed a few papers, among which may be mentioned one on "Influence Machines from 1788 to 1888," and two others on "Telephonic Investigations" and "Rotatory Converters."

Magnetism was a subject upon which Dr. Thompson was an acknowledged authority. He had collected a large number of manuscripts and early books on the subject, and at one time he projected the issue of a translation of Gilbert's "De Magnete." Largely owing to his influence, the Gilbert Tercentenary was held in 1903, and an oil painting by Mr. A. Ackland Hunt, representing Dr. William Gilbert showing his electrical experiments to Queen Elizabeth and her Court, was presented by the Institution of Electrical Engineers to the Corporation of Colchester. On that occasion Dr. Thompson made the presentation in one of his happy speeches, which unfortunately had to be curtailed for want of time. He was at his best under such circumstances, and although not an orator, he was a most effective speaker, always choosing the right word, and making his voice heard throughout a large hall without the slightest effort. He was fluent not only in English, but also in French, German and Italian, and his linguistic ability was of great service to the Institution in the various excursions they made to the Continent. Naturally he was chosen as a member of the International Electrotechnical Commission, upon which he was able to smooth many difficulties arising from other members not always grasping the exact meaning of what was said. If he had been born in an earlier age, we may be sure that he would have been able to converse in Latin also; as it was, he was an ardent student of early manuscripts in that language, especially of such as had reference to electricity and magnetism. Much of what he gathered from them he gave to the world in his Cantor Lectures of 1890 on the Electro-Magnet, which embodied the results of six years' work. Additional matter is to be found in his Presidential Address on Electromagnetic Mechanisms, delivered before the Institution of Junior Engineers. These lectures were expanded in his book "The Electro-Magnet," which has been translated into French, German and Russian. In June, 1901, he delivered the Boyle

Lecture on "Magnetism in Growth." In 1914 he delivered three lectures on Historic Magnetism, as Professor of Applied Physics in the University of London, and he has also published papers on "The Physiological Action of an Alternating Magnetic Field," and on "The Magnetism of Permanent Magnets."

Optics was another subject which claimed a great deal of Dr. Thompson's attention, and in the Proceedings of the Physical Society and the Transactions of the Royal Society there are to be found the records of many of his researches. Physical optics, geometrical optics, and harmonic analysis were all the richer for his experiments and mathematical deductions, and his volume of "Optical Tables" is one of the most useful books of reference on the science. At one time he was President of the Optical Society.

The chief work of Dr. Thompson's life was, of course, educational, and during the period 1878 to 1916 an enormous number of youths must have come under his direct influence, in addition to those who learned from his books. His own education commenced at the Friends' School, York, and was continued at the Founder's College, the Royal School of Mines, at Heidelburg, and elsewhere. He took his degree of B.A. at the London University in 1869, at the age of 18, and in 1875 he was bracketed first in science honours at London University, while he took the degree of Doctor of Science in 1878. That was the year, as already stated, that he became Professor at Bristol, but he had already been lecturing for some time in the University College there. In 1885 he was elected to the Chair of Physics at the City and Guilds Technical College, Finsbury, where he also became Principal, a post he held up to his death, last Monday. It would exceed the limits of our space to tell of all the posts he filled, of the many publications he made, and of the honours that were showered upon him. We may, however, mention that he was a Fellow of the Royal Society, of the Royal Astronomical Society, a member of the Royal Academy of Sciences at Stockholm, of the Academy of Sciences of Bologna, of the American Philosophical Society, Honorary LL.D. of Birmingham University, Honorary D.Sc. of Bristol University, Past-President of the Institution of Electrical Engineers, of the Physical Society, of the Institution of Junior Engineers, of the Optical Society, of the Illuminating Engineering Society, and of the "The Sette of Odd Volumes." On many occasions he represented this country at congresses and on scientific commissions. In addition to the books already mentioned and others, he wrote three scientific biographies: of Philip Reis, of Faraday, and of Lord Kelvin, the latter a masterly work in two volumes.

The parents of Dr. Thompson were members of the Society of Friends, and he adhered to that body all his life, joining in their worship and advocating their principles on fitting occasions. He exhibited many of the virtues which have long distinguished the Society of Friends, and his memory will be cherished by many whom he assisted in an unostentatious fashion when they were in difficulties. Few men inspired more affection, for he was always ready to lend a sympathising ear and a helping hand to those in difficulties. There is to be a "meeting for worship" at the Friends' Meeting House, 52, St. Martin's Lane, to-day (Friday) at 3.p.m., after the cremation, and at this meeting, it is announced, all his friends will be welcome.

NOTES.

A Progressive Steamship Company.

The opening, without ceremony, of the new Cunard building adjacent to the Liverpool landing-stage is a notable event, in view of the large part the company plays in the overseas trade of the country and of the continuous stimulus afforded by the management in the development of science associated with the maritime industries. Sir Charles Booth, Bart., since he became chairman, has more than maintained that patriotically British and technically progressive policy pursued by his predecessors. While ensuring the measure of safety and reliability essential in passenger liners, he has encouraged those responsible for design, notably his technical staff, to test proposals of a more or less experimental nature in new ships of the intermediate or cargo class with a view to their adoption in larger and faster ships, with the added advantage of modifications suggested by experience gained in service. The general confidence in turbines, first for direct drive, and later for drive through gearing, is due largely to Cunard enterprise, and we now learn of other proposals for determining in the merchant service the advantages of water-tube boilers, oil fuel and other systems of turbines with geared or electrical speed-reduction devices, which promise far-reaching effects. Moreover, the company are extending widely their lines of communication to the Dominions across the sea, and thus on other oceans than the Atlantic there is greater promise of advancement in the technics of steamship building. For these reasons the inauguration of the new Cunard building, as the centre from which such influences radiate, is fit subject for notice. The new building is on the site of part of the old George's Dock, authorised by Parliament in 1766, which is appropriate enough, since the Cunard Company have done so much to justify the extension, north and southward, of the Liverpool Docks. The neighbouring building is that of the Mersey Docks and Harbour Board, while on the other side of them is the building of an insurance company. Excepting that the latter is somewhat bizarre, the three buildings are attractive as well as prominent features, seen from afar, in the centre of the great harbour system. The façade of the Cunard building is towards the pier head, and is 170 ft. wide, the building broadening to 200 ft. at the frontage to the city, which is 330 ft. distant; the height from the basement is 125 ft., and from the foundations—on the red sandstone which underlay the old dock—170 ft. The floor area is over 20 acres. The architects have been happy in the appropriateness and effectiveness of the decorative features, the Cunard Company, maritime industry, and the alliance against Prussian dominance affording inspiration.

Road-Surfacing in Surrey.

In a paper contributed to the Journal of the Institution of Municipal and County Engineers by Mr. A. Dryland, County Surveyor for Surrey, the author states that early in 1914 plans had been adopted for the re-surfacing of 27 miles of road in the county. Included in this length were parts of the roads from London to Epsom, from London to Sutton, and of the Brighton road between Croydon and Crawley. The scheme was estimated to cost 92,000*l.*, of which part was to be contributed by the Road Board and part raised by loan. The net annual cost of the work was estimated at only about 5 per cent. more than the then annual cost of maintenance. Owing to the war this scheme has had to be curtailed and its execution delayed. The roads affected have water-bound macadam surfaces, which required tarring each spring, and again later on in the summer. Up till 1913 this plan proved fairly satisfactory, although there was some trouble from pot-holing and abrasion of surfaces in the spring, whilst the road was still too wet to be suitable for tarring. With the increase of heavy motor traffic, including busses, the difficulties of satisfactory maintenance increased, as new metal corrugated as soon as laid, so that the new coatings formed an uneven surface. Experience with long lengths of granite laid on these roads were very disappointing, while slag macadam proved on the whole satisfactory; but in view of the increasing traffic it was thought that it would be best still further to strengthen the roads. It was decided, accordingly, to lay two coats, the base to be made of bituminous macadam, and the surface of a carpet made with Trinidad asphalte, for the manufacture of which excellent sand was available in several places. The roads being already well metalled, the base coat could be made from the surface of the roads themselves by simply reforming it with the bituminous mixture. The sub-crust was generally 8 in. to 12 in. of old flint and gravel, covered with 3 in. to 6 in. of granite metal. The base being thoroughly well consolidated, it was only necessary to provide additional lateral support, which was effected by laying *in situ* a reinforced-concrete kerb or thrust wall, 9 in. deep by 4 in. thick. Three or four weeks after the laying of this kerb the granite surface of the road was scarified to a depth of 3 in. The material thus loosened was then removed, and after heating and drying, mixed with the proper proportion of pitch and oil. It was then relaid as a coat 2½ in. thick. Above this first layer was laid the carpet, consisting of 1 in. to 1¼ in. of an asphalte composed of 62 per cent. local sand, Kentish rag dust, and granite chippings; 10 per cent. of a filler, such as Portland cement, or other finely ground inert material, with a matrix of Trinidad Lake bitumen. The carpet was laid hot and cross-rolled, being finally dusted over with a little of the filler material. Carpets of this kind are, Mr. Dryland says, ready to take traffic as soon as cool. The surfaces thus constructed are stated to have proved satisfactory so far, and although there has been some corrugation, Mr. Dryland hopes that the estimated life of seven years will be justified by actual experience.

The Rating of Internal-Combustion Engines.

In a paper recently read before the Association of Supervising Engineers Mr. W. A. Tookey, M.I.Mech.E., stated that his practice was to disregard entirely the rated output of internal-combustion engines as given in builders' catalogues. This course was necessary because some makers rated the engine up to nearly its working limit under the most favourable conditions possible, whilst others were very conservative and allowed a considerable margin between the rated output of their engine and the maximum power which it was capable, under favourable conditions, of developing for a short period of time. His own method of estimating the output was based on the piston displacement per minute, and he gave the following table, showing the mean pressures which may fairly be expected with internal-combustion engines operating with different kinds of fuel:—

Piston Pressures (Lb. per Sq. In.) Obtainable from Internal-Combustion Engines for Use in Calculation of B.H.P. and Kw. Output.

1. Piston Pressures and Volumes.			Town Gas.	Producer Gas.		Fuel Oil.	Kerosene.	Petrol.	Two - Stroke Liquid - Fuel Crank - Case Compression.
				Anthracite.	Coke.				
Maximum Load.									
2	...	Pm	95	80	75	80	75	90	54
3	...	Pn	81	66	61	66	61	76	40
4	...	Em	0.85	0.825	0.814	0.825	0.814	0.845	0.74
5	...	Pw	54	44	40.7	44	40.7	50.6	26.6
Normal Full Load.									
6	...	Pm	90	75	70	75	70	85	47
7	...	Pn	76	61	56	61	56	71	33
8	...	Em	0.845	0.813	0.80	0.813	0.80	0.835	0.70
9	...	Pw	50.6	40.7	37.4	40.7	37.4	47.3	21.8
10	...	Vn	3	3.75	4.1	3.75	4.1	3.22	7.0
11	...	Vw	4.5	5.6	6.1	5.6	6.1	4.84	10.5
Long Periods Full Load.									
12	...	Vw	5	6.2	6.7	6.2	6.7	5.3	11.5
13	...	Pw	45.8	37	34.2	37	34.2	43	20

Pm = Mean effective pressure = indicator-diagram positive loop. (I.H.P.)
Pn = Useful piston pressure available at engine shaft. (B.H.P.)
Pw = Useful piston pressure available at generator terminals. (Kw.)
Em = Mechanical efficiency of engine = Pn ÷ Pm.
Vn = Piston displacement in cub. ft. per minute per b.h.p. developed (impulse strokes).
Vw = Piston displacement in cub. ft. per minute per kw. developed (impulse strokes).
(Values for Pw and Vw based on full-load generator efficiency of 0.89.)

The table shows that with town gas the mean indicated pressure will be as a maximum about 95 lb. per sq. in., but at normal full load only 90 lb. per sq. in. With kerosene as the fuel the corresponding figures are 75 lb. per sq. in. and 70 lb. per sq. in. respectively. In other portions of the table these mean pressures have been corrected for engine friction and other losses. The table further shows (line 11) that with town gas, for example, a piston displacement (impulse strokes) of 4.5 cub. ft. per minute will be required to develop 1 kw., whilst if the engine is to run at full load for long periods this figure should (as indicated in line 12) be raised to 5 cub. ft. per minute.

LITERATURE.

Brassey's Naval Annual, 1916. Conducted by EARL BRASSEY, G.C.B., D.C.L. Edited by JOHN LEYLAND. London: William Clowes and Sons, Limited, 31, Haymarket, S.W. War Edition. [Price 10s. net.]

As Viscount Hythe is still engaged upon important war work, Earl Brassey has taken up the task, congenial to him and profitable to all readers of contemporaneous naval history, of directing the preparation of the Naval Annual, still, as always, the leading exponent of current naval history, strategy and tactics. He concludes his introduction to this year's volume with a characteristically wise dictum: "It is a duty to keep clear of controversy," and although he is too wise a statesman to dictate to the contributors of the volume, it is a remarkable coincidence that, while there is much of helpful guidance in the various chapters, there is nothing of baneful controversy. In his introduction Lord Brassey discloses that great breadth of view which has dominated all his contributions to naval literature. It is brief but pointed, and clearly enforces some of the lessons of the present world-war. He points out that the further the track of merchant shipping is from the base on which the enemy depends, alike in respect of submarine and torpedo craft, as well as commerce raiders, the better the chance of safety. Therefore he commends the policy of an earlier Board of Admiralty in creating a base at Simon's Bay. We notice also the further suggestion, not here recorded, of similar provision at the Falkland Islands. Nearer home, his Lordship contends that the ports to which trade should be directed in war ought to be those best reached from the main highways of the sea; Falmouth, the West Coast of Ireland, Liverpool and Glasgow offering preferable advantages as compared with the Thames and the Humber. There is here obvious suggestion for activity by railway as well as harbour authorities before war necessities make improved shipping and railway transport facilities necessary. It is natural that such a great Imperialist should also enforce the importance of self-governing States beyond the seas having a voice in councils dealing with the foreign affairs of the Empire. To ward against international conflict, Lord Brassey also urges the view that there should be no interference by States in the domestic quarrels of other States. As to the future defence of the Empire, his view is that the shipbuilding votes should be not less than double those of any European Power; that a consultative council, consisting of a few officers of the widest experience, should be constituted to examine and report upon the designs of all new ships to be built in accordance with Admiralty policy before they are submitted to the Admiralty Board; and further, that the standing army should be greatly increased, with a trained reserve, including every man of military age capable of bearing arms.

The Naval Annual sheds a considerable amount of light on the types of vessels laid down since the outbreak of war, by the collation of facts disclosed officially either in the speeches of members of the Board of Admiralty, or in the Admiral's despatches in connection with naval and other operations. That much has been done towards the building up of a new powerful fleet of vessels designed as the result of experience in naval operations is widely known. The time, obviously, has not come for writing at any length on this question. Lord Fisher's return to the Admiralty marked, by no mere coincidence, the beginning of the new shipbuilding policy. The new wave of impulse and enthusiasm which he gave resulted in "an ever-swelling tide of deliveries of craft of all kinds best suited to the purposes of this war." Commander Charles N. Robinson, R.N., in his very lucid historical narrative of the naval operations from the beginning of May 15, 1915, to March, 1916, as a continuation of a corresponding contribution in last year's Naval Annual, points to the value of what have been termed in seamen's colloquialism "blister ships." "Just below the surface the sides are made to bulge out some 10 ft., and then curve in. A torpedo striking this bulge will probably not damage the hull, but will explode amidst a variety of substances." This, it will be realised, is a most important protection against torpedo attack, and it has been applied not only to the old cruisers of the Edgar type, which were sent to the Dardanelles immediately after the arrival there of the German submarines, but to many new ships, including mine-sweepers, named after common flowers, and therefore regarded as the "herbaceous border" of the fleet, and to other craft. Monitors and other ships thus designed have proved of great advantage, particularly in amphibious warfare, being able to stand up against torpedo attack. The monitors are fitted with powerful armament, some having 14 in., some 9.2-in. and 6-in. guns, and others only 6-in. guns. These monitors, it will be remembered, were developed from the three ships designed and built by Messrs. Vickers for the Brazilian Government and taken over immediately after the war, primarily to assist the land forces in Flanders by shelling the right wing of the German forces in the operations in Flanders. The adoption of the "blister" system, and the greatly increased power of armament were valuable developments, which are suggestive of similar additions to the offensive and defensive qualities of our newer ships. Commander Robinson has a well-merited compliment to pay to the merchant service, commending, in no uncertain language, the fitting of guns to those vessels, in order to fend off attack by submarines. "Never before in its long and splendid history has the merchant navy added greater glories to its record than by the way it has met this 'organised campaign of piracy and damage'; " and no better testimony to its officers and men could be found than is contained in the list circulated by the German wireless of February 26, 1916, of eighteen actions in which merchant ships resisted submarine attacks. The work of the navies of our Allies comes in for equal credit with that of the British fleet, and Commander Robinson's complete knowledge of naval history enables him to draw parallels and "point the moral" of many episodes in his review which will be of great value in future analyses of the significance of the naval operations. One of his points may be brought out, and that is, that, taking the average value of British tonnage at 10*l.* per ton, the value of losses in the merchant service represents merely 7 per cent. of the total.

Mr. John Leyland, the Editor of the Naval Annual, contributes a chapter on "Strategy and the War," which ought to be read by everyone, especially by those who were impatient with the long period when little or nothing was heard of that "silent pressure" of the Navy which has continuously proved invaluable in the progress of the war. A lifelong naval student, Mr. Leyland writes with full knowledge and enforces the advantage of the maintenance of sea power. Germany, having possession of internal railway communications, is able to move her troops from any one point in the far-flung battle line, from Ostend in the west to Bagdad and Aleppo in the east, from Kiel in the north to Trieste in the south, and from Verdun to Lemberg. But the closing of the gateways of the ocean and the absolute suppression of enemy commerce at sea, resulting from the operation of naval pressure by Britain and her Allies, constricted the life-stream of the Germanic peoples, bringing misery, and, it may be, ultimate acquiescence in the demands of their enemies. For instance, the direct exports from the United States to Germany, valued at over 31 million sterling in 1914, fell to 2,357,770*l.* in 1915, while the drop in the case of United States exports to Austria was from over 2¼ millions sterling to 20,905*l.* It was semi-officially declared two months before the outbreak of war that the economic prosperity, and even the very life, of Germany depended upon foreign commerce. "Her distant possessions were to be protected by sea power. One-third of the national requirements in foodstuffs came from abroad, and a proportionate part of the population depended upon foreign supplies, two thirds of which came by sea." The distant possessions have fallen one by one; the foreign commerce, which was vital, has disappeared; and the fleet, whose power or influence was so bitterly necessary, has remained inactive. This anomaly and the inaction of the main body of the German high-sea fleet is explained by the fact of our superiority at sea and our greater mobility. We have not yet fought our Trafalgar of this great war, but we have established our superiority, and will continue to do so even should the German fleet not again debouch from her mine-locked harbour to challenge our supremacy. Incidentally, too, Mr Leyland points to the importance of our holding the German land forces at Salonica, as the possession of such a port by Austria-Hungary or Germany would be a menace to our Mediterranean connection with our great dominions beyond the seas.

An equally illuminative chapter is that by Sir Francis Taylor Piggott, formerly Chief Justice of the Supreme Court of Hong Kong, and a high authority on the rights of belligerents and neutrals. His contribution is on "Neutrals and the War," and he establishes the correctness of the British attitude throughout.

A careful analysis of the 24 air raids made on Britain by Zeppelin and other airships shows that on only two occasions did the velocity of the wind exceed 25 miles per hour and on three others 13 miles. On all other occasions the velocity was from one to eight miles. From this there is justification for the deduction made by an anonymous writer in the Naval Annual to the effect that such enterprises are only possible in favourable weather. Moreover, the loss of many airships destroyed prior and subsequent to the outbreak of war have been due to the action of the wind. Again, the great majority of the raids took place at or about new moon or in the first and last quarters of the moon. He comes to the conclusion that the Zeppelin commander must choose some dark night in which the atmosphere is still, or in motion with light winds only. Even where the wind exceeded 25 knots a hasty retreat was made. The captain, too, has always to contemplate the possibility of having insufficient fuel to cruise for a satisfactory landing during high winds. Strong breezes are the worst enemy of the Zeppelin; thus it should be recognised that there are limitations to their use as scouts for the naval fleets in the North Sea and the Channel. Under favourable conditions, it is true, they are more useful than cruisers, because their range of vision is greater; but in a heavy wind the aeroplane is of greater service, although it cannot remain so long in the air or normally undertake distant flights. Nevertheless, the airship is a valuable auxiliary to the fleet, and for this reason there is not room for anything but regret that the building of such craft for us was discontinued years ago, when the Admiralty learnt their first, and probably most valuable, lesson from the failure of the first of our flying ships. The newer German ships are undoubtedly of increased strength and greater engine power, probably exceeding 1000 horse-power, but the writer of the article in the Naval Annual is confident that the gun defence is having influence on Zeppelin attack, and, further, that the darkening of the places that may be attacked deceives airships as to their whereabouts.

As regards aeroplanes, he points to the need for machines of various types. For naval patrol work the engines would have to be of 350 horse-power. For aircraft for distant scouting fuel capacity and wireless telegraphic apparatus must give considerable range. Attacking aircraft, on the other hand, may be classed as those adapted for bomb-dropping, those having a gun equipment, and those called the "battle-plane type," possessing considerable engine and fighting power. Each of these types involves definite and different problems in design. The size of gun again is one of considerable importance in the design of the aeroplane. "The wind resistance of the gun itself is a disadvantage, not so much because it may reduce speed, nor because the gun, when turned from side to side for firing, may act much as does a front rudder, but because of the disturbing effect on aim of the wind pressure on the gun as it is being turned about for aiming." With a quick-firing gun a problem is introduced in the matter of the gun's reaction on the aeroplane. "It has been estimated that 100 shots a minute would give 3300 lb. backward momentum to the aeroplane, and the backward retardation of an aeroplane of ordinary weight would therefore be about 2 ft. per second, for each second of firing time. This would cause a loss of speed to the aeroplane of nearly seven miles an hour for every five seconds during which firing was continued." The writer

holds the view that an aeroplane can ascend to a greater height than a Zeppelin, and that the ascensional power should be equal to giving a rise of 1000 ft. per minute. Size is essential for this. But referring to Mr. Lanchester's contributions to ENGINEERING, he seems to suggest that there are possible advantages in triple or quadruple plane types, or in entirely new wing forms, in order to ensure higher speed and lifting power with moderate spread of wings.

As regards the phrase "command of the air," the writer in the Naval Annual doubts if there is complete understanding as to what the phrase means. He asks a series of questions which show that there cannot be the same supremacy in the air as on the sea. "Can the air ever be so commanded—as the sea is commanded—that enemy aircraft can never fly at all? Can we ever forbid an airship from flying on a still dark night, and dropping bombs ere the dawn? Something of command might be gained if we could destroy all the enemy's airships in their sheds, but who can say that aeroplanes, starting from 100 centres, may not yet be able to cross the sea? Can aircraft ever prevent armies from going afloat as command of the sea does, or sweep the enemy's commerce from the seas?" At the same time he enforces the view that it is not true to say that aeronautics have profoundly modified strategy by sea and land. Strategy is changeless in its principles, though by extending the range of observation and report concentrations and movements may be detected and checked.

Tribute is paid to the engineers of the service in the chapter in the Naval Annual by Mr. Alex. Richardson, which deals with "The War and Some Portents of Naval Machinery Design." The remarkable freedom from breakdowns due to normal causes, associated with the almost continuous high-speed steaming in all kinds of weather and under varied conditions, speaks greatly for those responsible for the design and construction of naval machinery. Moreover, in all fights our ascendancy was established also in respect of speed, which is not only a great strategic, but a valuable tactical advantage. Little, of course, can permissibly be written regarding present developments in navy machinery, but it is shown that the interposition of gearing between very high-speed running turbines and relatively slow rotating propellers has conferred enormous advantage. Indeed, it is pointed out that, "when Sir Charles Parsons applied this idea in the Vespasian in 1897, he met with very considerable doubt as to its reliability and efficiency, but there can be no question that in this departure he did as great a service to ship propulsion as by the introduction of the steam turbine itself; and when the history of the past year's shipbuilding can be told completely, it will be found that the gearing has proved itself suitable to all powers, even the greatest." It is now almost a universal practice, and is being freely adopted in the merchant service. A moderate estimate of the gain in coal consumption is put at 7 per cent., and the reduction in weight as over 11 per cent., as compared with direct turbine drive, which, in its turn, has shown itself enormously more economical than reciprocating machinery. The principle of reducing speed in two stages is now being applied, and thus the propeller is driven at something like nearly 1/25th the number of turbine revolutions. The position as regards the introduction of electrical transmission between the turbine and the propeller is examined, and the installation on board the United States battleship New Mexico is described. It is shown here that the machinery adopted, excluding boilers and condensing auxiliaries, is estimated to weigh 530 tons, and that the turbine machinery designed for the ship would have weighed 653 tons, but it is added that "in such a comparison it is always difficult to say whether the best has been made of either design." The steam consumption guaranteed is 11.9 lb. per shaft horse-power per hour at full speed, 11.1 lb. at 19 knots, 11.4 lb. at 15 knots, and 14.6 lb. at 10 knots. The penalty is 5000*l.* per lb. of steam consumption in excess of those stated for the two lower speeds, and 4100*l.* per lb. of steam for the higher speeds. In other cases, however, a consumption distinctly lower—namely, 10.8 lb. at full power—has been guaranteed. The advent of the Ljungstrom turbine, the construction of which has been taken up for naval purposes in this country by Sir Wm. Beardmore, is also dealt with, and here it is shown that the steam consumption may be reduced to 9 or 10 lb. per shaft horse-power per hour for all purposes, a result which, it is indicated, has induced the fitting of the system in an intermediate trans-Atlantic liner "by a British company, which has shown the way not only in speed of liners, but in the introduction of machinery systems of novel but promising type." The limitations of speed in submarines, due to oil-engines, are also referred to, and there is suggestion that submarine designers may be forced to employ steam plant in order to meet the demand for a surface speed of 25 knots or more, which, so far, has been impossible with the oil-engine.

Mr. John Leyland writes the concluding chapter in the first part of the Annual. It is on the United States Navy, and deals with the five-year programme recommended by the General Board, and with the design of new ships. There are also given the usual tables of warships and airships, and elevations and plans of the leading ships of all navies, except the British. Some notes are included regarding gun and armour-plate work in America, while the further tables include the ballistics of guns of various powers and makers. There are also many official documents in reference to the war. In the concluding part is an Appendix with Lord Brassey's farewell to his yacht the Sunbeam, which, after serving as a hospital ship in the Mediterranean, has been handed over by his Lordship as a gift for service to the Indian Government. The inclusion of this ceremony of handing the ship over is justified not only because the Sunbeam is an historical ship, but because it discloses in a most interesting form the love of the sea and the skill as a seaman of Lord Brassey, who is to be congratulated on the admirable character of this, the latest of a long series of Naval Annuals, which have been of immense service in stimulating interest in naval affairs and in the provision of the means now being triumphantly utilised for maintaining British supremacy on the high seas.

BOOKS RECEIVED.

The "Electrician" Electrical Trades' Directory and Hand-Book for 1916 (Thirty-Fourth Year). London: The *Electrician* Printing and Publishing Company, Limited, Salisbury-court, E.C. [Price 15s. net.]

The Mercantile Year-Book and Directory of Exporters, 1916. Edited by WALTER LINDLEY-JONES, F.R.G.S. London: Lindley-Jones and Brother. [Price 10s. net.]

Glasgow Shipping, 1916 *Edition: A Complete Directory, Personal and Official, to the Shipping and Allied Interests in the Port of Glasgow, including Greenock and Port Glasgow.* Glasgow: *The Journal of Commerce* Offices. [Price 1s.]

The Navy League Annual (corrected to January 31, 1916). Edited by ROBERT YERBURGH, assisted by ARCHIBALD HURD and GERARD FIENNES. London: John Murray. [Price 5s. net.]

United States Department of the Interior. Bureau of Mines. Technical Papers. No. 104: *Analysis of Natural Gas and Illuminating Gas by Fractional Distillation at Low Temperatures and Pressures.* By G. A. BURRELL, F. M. SEIBERT, and I. W. ROBERTSON. No. 111: *Safety in Stone-Quarrying.* By OLIVER BOWLES. No. 115: *Inflammability of Mixtures of Gasoline Vapour and Air.* By G. A. BURRELL and H. T. BOYD. No. 120: *A Bibliography of the Chemistry of Gas Manufacture.* By W. F. RITTMAN and M. C. WHITAKER. Compiled and arranged by M. S. HOWARD. Washington: Government Printing Office.

United States Department of Commerce. Coast and Geodetic Survey. Serial No. 9. *Geodesy. Application of the Theory of Least Squares to the Adjustment of Triangulation.* By OSCAR S. ADAMS. Washington: Government Printing Office.

Elements of Highway Engineering. By ARTHUR H. BLANCHARD, C.E., A.M. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 12s. 6d. net.]

Engineering Thermodynamics. By JAMES AMBROSE MOYER, S.B., A.M., and JAMES PARK CALDERWOOD, M.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 8s. 6d. net.]

Electrodinámica Industrial. Par José O. PÉREZ DEL PULGAR, S.J. Tomo I. *Teoría General de los Campos de Fuerzas Electromagneticos.* Madrid: Establecimiento Tipografico de Portanet.

The Structure and Properties of the More Common Materials of Construction. By G. B. UPTON. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10s. 6d. net.]

Hand-Book of Carburetion. By ARTHUR BENJ. BROWNE. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 8s. 6d. net.]

INDUSTRIAL NOTES.

THE Labour Advisory Committee, announced by the Rt. Hon. Walter Long, M.P., during the progress through Parliament of the Military Service Bill, is now sitting. It consists of Mr. G. J. Wardle, M.P. (Chairman), Mr. Charles Duncan, M.P., and Mr. Stephen Walsh, M.P. Its main functions are:—

1. In connection with the Recruiting Department of the War Office, (*a*) to act as a medium for sifting and communicating any labour complaints against the Recruiting Department; (*b*) to deal with allegations as to industrial compulsion; (*c*) to facilitate labour measures for getting men for the Army, including men wanted as artizans for Army work.

2. In connection with the Reserved Occupations Committee, to consider (*a*) changes in list of certified occupations; (*b*) other matters requiring special action as to particular trades.

3. Generally to keep the Government informed, through the President of the Local Government Board, of any labour matters affecting military service which call for attention.

The Committee is sitting daily at the Central London Recruiting Offices, Great Scotland Yard. All communications should be addressed to the Secretary, Room 2, Great Scotland Yard, Whitehall, S.W.

The following letter was addressed last week by the Ministry of Munitions to the Shipbuilding Employers' Federation and the Engineering Employers' Federation and is issued to the Press for publication:—

"I am directed by the Minister of Munitions to refer to the interview which members of your Federation had with Dr. Addison on the 6th June in regard to certain questions arising with respect to the postponement of the Whitsun holiday, and to make the observations set out below on each of the principal points raised. In doing so I am to point out that in view of the unparalleled circumstances under which the present action is taken, this action cannot be taken as in any way a precedent for future occasions.

"1. In cases where extra allowance of pay for work during the deferred holiday is made in accordance with the Prime Minister's statement, upon whom will the extra financial charge fall? On this I am to reply as follows:—

"(*a*) as regards controlled establishments, any extra expenditure proved to have been incurred by them through payment of an enhanced rate of wages in accordance with the Prime Minister's statement will be allowed as an expense to be deducted in determining the profits under the Limitation of Profits Rules. This will cover private work in the establishments as well as munitions work; (*b*) as regards uncontrolled establishments undertaking work for the Ministry of Munitions and the Admiralty, where it is proved that the extra expenditure incurred through payment of an enhanced rate of wages in accordance with the Prime Minister's statement has been such as to involve clear hardship, the Minister and the Admiralty will be prepared to consider the cases with a view to any necessary adjustments. This will apply also to any controlled establishment in whose case it is proved that there is no margin of excess profits against which the expenditure could be set.

"2. In the case of a district where there has not been a universal custom or practice, but some shops have made these special allowances and others not, what is to be done in the case of the latter?

"As regards this question, I am to state that the view taken by the Minister is that the attitude to be adopted in each individual shop, in the absence of a definite agreement or custom for that shop, must be determined by what was the ruling practice in the district.

"3. In certain shops there may be agreements affecting certain classes of workpeople and not others, or agreements providing different rates of additional pay for different classes of workpeople. What is to be done in these cases?

"In reply, I am to state the view of the Minister as follows:—

"(*a*) Where any class of workpeople in a shop receives additional pay under an agreement, it will in general be found necessary that other classes (including women employed in the same shop) should receive some additional payment. (*b*) At the same time it appears quite admissible that for any good cause (in particular definite agreements) there should be different additional rates for different classes of workpeople, even in the same shop.

"4. It has been suggested that in some cases claims for extra pay unwarranted by any agreement or custom, or by the terms of this letter, may be put forward. Such claims should not be entertained. The postponement of the holiday was required in the national interest, and the Minister was confident that under these circumstances no demands would be pressed to the extent of declining to work. Any point of real doubt can and should be made the subject of subsequent arbitration."

Sir George Askwith, who went to Manchester last

week with reference to the cotton trade dispute, held a number of meetings with the representatives of the employers and operatives. The Lord Mayor of Manchester and the Town Clerk received him officially and expressed the hope that a settlement of the dispute would be arrived at. It was announced towards the close of the week that the notices were withdrawn, and that both parties would abide by Sir George Askwith's terms of settlement. On Monday last Sir George's award was made known. It is to the effect that "the operatives are to receive an increase of 5 per cent., to be paid on and after the pay day in the week ending the 10th inst. No alteration is to be made in the piece lists and present wages during 1916, and six weeks' notice is to be given after December 31 for any further alteration." The representatives of the operatives received the decision with marks of disappointment. It will be remembered that they had asked for an increase of 10 per cent. The whole question will no doubt be raised again early in February next.

At the annual general council meeting of the National Transport Workers' Federation held at Glasgow, on Friday last, a resolution which was moved against military conscription was defeated. Speaking in favour of conscription, Mr. Ben Tillett said that out of 5,000,000 men at the front 4,800,000 belonged to their class. Out of that number, if a plebiscite were taken, 90 per cent. of them would be conscriptionists. "The nearer you get to the firing line," he proceeded, "the more conscriptionists you find. The most vehement demand for conscription made to me was by those men. We trade unionists are coercionists, and in a strike absolute conscriptionists, and God help anybody who is a conscientious objector. Let us realise that this war is much more than a strike, and although I endorse the anti-compulsion view, I don't want our membership to gain the impression that we are all pacifists and anti-warites. Lord Kitchener played the game straight with us all the way through. I deny that in the action some of us have taken that we have been jockeyed by statesmen, and I repudiate that we have sold the pass."

We read in the *Yorkshire Post* that an official statement has been issued by the Yorkshire dyeing industry employers, in which they say that the details of the offer for an increase in wages made to the operatives at the conference on Friday last were as follow :—

1. 2s. per week to all workmen over 18 years of age, making an increase on pre-war rates of 5s. per week ;

2. 1s. per week to youths under 18 years of age and to women and girls, making an increase on pre-war rates of 3s. per week ; and

3. 5 per cent on the earnings of piece-workers, making an increase of 15 per cent. on pre-war rates.

These advances were to be regarded as war wages, and recognised as due to and dependent on the existence of the abnormal conditions now prevailing in consequence of the war, and neither party should, before the signing of peace terms, seek to alter this arrangement except on the ground of material alteration in the cost of living. This arrangement should, thereafter, be terminable by three months' notice in writing from either party.

The employers also suggested :—

(*a*) That the agreement of October, 1915, along with the official Board of Trade statistics of the cost of living be taken as the datum ;

(*b*) That a joint committee of employers and employed be constituted ; and

(*c*) That the committee consider the war grants quarterly on August 20, November, 20, &c., make such recommendations as changes on the datum justify, and that recommendations so made come into operation on the first pay day in the following months.

The men refused the offer, but it is expected that further suggestions will follow.

The Norwegian labour conflicts have entered upon a new phase, inasmuch as the men within the mining and iron industries have rejected the agreement which their representatives at the negotiations had accepted, and which have been accepted by the organisations of the employers. It will now be necessary for the men to hold fresh meetings in order to discuss what further steps may have to be taken.

An important agreement has been arrived at on the Clyde in regard to dilution of labour. Negotiations had been in progress for some time between the Commission for the Dilution of Labour on the Clyde and the Tyne (as represented by Mr. Lyden Macassey, (Chairman), Sir Thomas Munro and Mr. J. H. Mitchell), and the Local District Committee of the Boilermakers, the Iron and Steel Shipbuilders' Society, and the Ship Constructors and Shipwrights' Association, with a view to agree upon the necessary procedure and details. On June 8, Mr. Balfour addressed a letter to Mr. Macassey, urging the dilution of labour with the object of increasing the number of skilled men available for Admiralty work. In view of Mr. Balfour's letter, the Commission and trade unions concerned have hurried negotiations to a speedy conclusion, and on June 10 the following important agreement, referred to above, was made between the Commission and the Clyde and West of Scotland District Committees of the Boilermakers' and Iron and Steel Shipbuilders' Society. It provides for :—

1. Co-operative efforts to increase production by the adoption of all expedients which tend to increase and maintain the output.

2. The interchangeability inside the boiler-makers' and iron and steel shipbuilders' trade of the various classes of persons who are members of that trade, and with that purpose in view the suspension for the period of the war of all internal lines of demarcation.

3. Utilisation to the best advantage of the existing skilled men or skilled men interchanged, and the use so far as practicable of pneumatic, hydraulic and electric tools.

4. Up-grading in the boilermakers' and iron and steel shipbuilders' trade of workmen to do more skilled work wherever the nature of the work and the qualifications of men make such procedure practicable.

5. The introduction into the boilermakers' and iron and steel shipbuilders' trade of (*a*) skilled men from allied trades, (*b*) skilled men from other trades, (*c*) unskilled men and women in all cases where the work is of such a character or the conditions such as to enable the labour introduced to perform the work with reasonable efficiency.

6. The relaxation of the existing demarcation restrictions for the admission of semi-skilled or female labour not to affect adversely the rates customarily paid for the job. In cases where the men who ordinarily do the work are adversely affected thereby, the necessary readjustments shall be made so that they can maintain their previous earnings.

7. A record of the nature of the departure from the conditions prevailing when the establishment became a controlled establishment to be kept.

8. Due notice to be given to the workmen concerned, whenever practicable, of any changes of the working conditions which it is desired to introduce as the result of the establishment becoming a controlled establishment, and an opportunity for local consultation with the workmen or their representatives to be given if desired.

Mr. Balfour has expressed his gratification at the patriotic response of the Clyde District Committee and the West of Scotland District Committee of the Boilermakers' and Iron and Steel Shipbuilders' Society to his appeal.

It is stated that the Commission has practically arrived at a similar agreement with the District Committee of the Ship Constructors' and the Shipwrights' Association.

THE LATE SIR H. FREDERICK DONALDSON.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of June 9 it is stated that the late Sir Frederick Donaldson resigned his work at the Arsenal on account of ill-health. The Minister of Munitions desires me to point out that this statement is not in accordance with the facts. At the request of Mr. Lloyd George, Sir Frederick Donaldson temporarily gave up his position as Chief Superintendent of Ordnance Factories in order to act as his technical adviser at the Ministry of Munitions.

I hope you will see your way to make this correction in your next issue.

Yours faithfully,
J. T. DAVIES.

Whitehall Place, S.W., June 13, 1916.

[We willingly publish the above letter and regret that the circumstances connected with the transfer of Sir H. Frederick Donaldson from Woolwich to the position of technical adviser to the Minister of Munitions should have been incorrectly stated in our memoir.—ED. E.]

CANADIAN LIFT-LOCKS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the description of the canal lift-locks given in your last issue I notice what I feel sure is an error. On page 549 you mention the lifts at La Louviere in Belgium, Les Fontinettes in France, and the *Darlington* lock or lift in England. Surely you mean *Anderton* in England. Had your contributor referred to the Proceedings of the Institution of Civil Engineers, vols. xlv. and clxxx., he would have found a full description of the original construction of this lift in the first mentioned volume, and a full description of its life and reconstruction in the second volume.

The reconstructed lift has so far continued to work satisfactorily and with less maintenance cost than the original ; also, as everything is visible and accessible and the two troughs independent, any repairs can be carried out without stopping the traffic. In cold weather there are no hydraulic pipes to freeze, and the only trouble is when a heavy fall of snow clogs the gearing. This, however, is easily removed, and, in a new lift, could be obviated altogether by roofing in. The cost of operation is small, being about one Board of Trade unit of electricity for each stroke on the average ; sometimes it is much less than this, depending on the height of the canal and consequent depth of water in the caisson.

At Anderton it was not possible to arrange for controlled variation in the water-level, as existing circumstances had to be considered, but in any new lift arrangements could be made for adjustment, so that beyond the initial starting current the stroke would be performed automatically by the weight of water. Altogether, for the reasons given in the above-mentioned volume clxxx., I prefer the electrically to the hydraulically operated lift.

While on the subject of canals, may I point out how much it is to be regretted that nothing has yet been done to improve them in this country ? Had the scheme outlined by the Royal Commission in 1906–09 been even partially complete, it would have been invaluable during the last two years, and would have, in my opinion, already more than paid for itself.

However, the past cannot be recalled, and we can only look forward to the time when we shall as a nation realise the necessity for conserving our sources of energy, and, *inter alia*, arrange for the transport of bulk merchandise by methods which require the least possible expenditure of our mineral resources.

I have, &c.,
J. A. SANER, M. Inst. C.E.

River Weaver Navigation, Engineer's Office,
Northwich, Cheshire, June 12, 1916.

[Mr. Saner is correct in assuming that the word "Darlington" in our article should have been "Anderton." The first Anderton lift, we may add, was fully described and illustrated in ENGINEERING of September 12, 1884.—ED. E.]

LABOUR EXCHANGES AND TECHNICAL STAFF APPOINTMENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent "Badgered," whose letter appeared on page 551 of your last issue, displays the reason why engineering draughtsmen receive the treatment mentioned in previous letters. The total lack of any sort of organisation amongst this class of labour is deplorable and prevents them receiving any more than mere casual consideration as a body, and in the future points to an even worse state of affairs when labour is plentiful.

The numbers of draughtsmen working for wages less than the shop mechanic are remarkable, many of them, to common knowledge, receiving from 30s. to 45s. per week and conditions to suit. One prime reason of the above state of affairs is, we think, the independent ideas of so many—that to be organised puts them on the plane of a mere workman. They forget such examples as the teachers and medical men.

Now that organisation has shown its points during the present crisis, what reason can they have for not following suit and preparing for what is to come after the war ? We suggest that some conference should be called in different towns of engineers on technical staffs for a discussion, to be followed by a central one in some convenient centre, of delegates to frame rules, &c., as a step towards better and greater things.

We remain, yours sincerely,
June 8, 1916. TECHNICAL ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—I should be much obliged if you would publish the following in reply to your correspondent who signed himself "Technical" (see page 536 of your issue of the 2nd inst.), and suggests that draughtsmen should organise to combat this inconsiderate and unfair Act. There is at the present time an association formed for the purpose of furthering the interests of draughtsmen, and this same question is being considered by them. An extract from the latest report of the association is as follows :—

"The General Council have had under consideration the terms of the Munitions of War Acts so far as affecting draughtsmen, and they think it is unfortunate that these Acts do not contain provision for the benefit of draughtsmen. A great many cases have been brought before the General Council where members of the association might have improved their positions, but owing to the restrictions in connection with transfer they have been prevented from doing so.

"The Council have in view to make representation to the Ministry of Munitions in connection with any further amendments of the Act, so as to give better facilities for transfer."

I may say the association is not a trade union ; its constitution is similar to the Class Teachers' Association.

Now is the time for us to organise and raise the status of a profession of first importance.

The secretary, Mr. Louis Blair, 94, Hope-street, Glasgow, will, I am sure, be delighted to send full particulars.

I remain, yours truly,
June 8, 1916. FAIR PLAY.

NEW KRUPP WORKS.—The firm of Fried. Krupp, Essen, is about to start a Bavarian branch in Munich. The capital will be between 20,000,000 marks and 30,000,000 marks, of which the Krupp firm finds a portion, the rest being subscribed by Bavarian banks and leading industries. That the Essen firm does not itself supply the entire capital is owing to a desire to bring about a closer co-operation with Bavaria. The firm of Fried. Krupp has entered upon a number of undertakings in regard to the new works to aid the manufacture, and also, it is stated, with reference to dividends, &c., probably on similar lines to the Krupp arrangement with the Hamm Wire Company, which guarantees the latter company a minimum dividend, and when the Fried. Krupp Company pays more than 7 per cent., then a share in the profits.

COILING MACHINES FOR SPRINGS.

THE illustrations on this page show a machine which is probably the largest cold coiler ever built. It has been recently designed and constructed by Messrs. Sleeper and Hartley, Inc., of Worcester, Massachusetts, U.S.A., and an idea of its size and power may be gathered from the fact that it weighs about 7 tons and covers a space of 6 ft. by 8 ft. It will handle $\frac{3}{8}$ in. oil-tempered wire, coiling and cutting automatically at a speed of about 50 ft. per minute. It will make either extensive or compressive springs, and will feed as much as 100 feet of wire into a single spring.

The acting side of the machine, which deals with the wire, is shown in Fig. 1, and the opposite side in Fig. 2. Fig. 3 shows the coiling mechanism to a larger scale. This mechanism is noticeable from the fact that the spring is not produced by being coiled round an arbor, but by the wire being fed forward against a coiling point or deflector, the machine putting a predetermined amount of wire into each spring, and then stopping while the spring is being cut off. There is an arbor, but its sole purpose is to provide a cutting edge against which the exterior cutter may carry the wire for the purpose of shearing it off after each spring is coiled. Adjustments are provided for the feed or amount of wire which can be fed into any one spring; and the diameter and pitch, as well as the contour of the spring, may be changed instantly by means of adjustments provided throughout the machine. The diameter and contour forming mechanism is controlled by means of a cam, these cams being so designed that

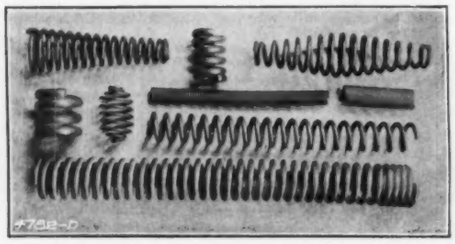


FIG. 4.

only a single cam is needed to produce any kind of a taper spring, and a single pair of cams for producing every conceivable variety of barrel-shaped springs (Fig. 4). The pitch is controlled automatically, and springs may either be produced with an open spiral, or the end coils may be "flatted," or laid close, to as great an extent as desired.

It will be obvious that next to being able to form springs of any desired contour, the greatest advantage which results from using these machines is in the control of the pitch, and the ability to produce springs with squared ends, thereby eliminating the very expensive and costly method of squaring the ends of the springs by heating and pressing.

The machine illustrated is the last of a series of which the remainder are smaller in a graduated order, as shown in the subjoined table.

No.	Wire Range.	Feed.	Coil Range.	Output.	Floor Space.
	in.	in.	Inside diameter. in.	Per minute.	in.
0	0.004 to 0.015	18	$\frac{1}{32}$ to $\frac{5}{8}$	150 to 200	12 by 18
1	0.012 to 0.062	36	$\frac{1}{4}$ to 1	50 to 150	18 by 28
2	0.034 to 0.135	50	$\frac{1}{2}$ to 2	35 to 100	26 by 40
3	0.105 to $\frac{3}{8}$	6 in. to 50 ft.	$\frac{3}{4}$ to $2\frac{1}{2}$	100-ft. wire	42 by 56
4	0.162 to $\frac{1}{2}$	1 ft. to 100 ft.	1 to 4	100-ft. wire	60 by 70

Nos. 0, 1 and 2 are not recommended for the making of close-coiled or extension springs owing to the fact that they are not adapted to feed any great quantity of wire into a single spring. The large machines will make either extension or compression springs, and will feed as much as 100 ft. of wire into a single spring.

BORDEAUX FAIR, FROM SEPTEMBER 5 TO 20, 1916.—The town of Bordeaux has decided to inaugurate a Bordeaux Fair, which will be held on the splendid Square of the Quinconces, from September 5 to 20 next, and will take place every year in the future. It will be open to all traders, inventors, makers and dealers from France, the Colonies and Allied and Neutral countries. The offices of the Committee and of the Administration are at the Town Hall. Application may be made there for booklets and tickets of admission. The list of entries will be closed on July 20 next.

HEAVY SPRING COILING MACHINE.

CONSTRUCTED BY MESSRS. SLEEPER AND HARTLEY, INC., WORCESTER, MASS., U.S.A.

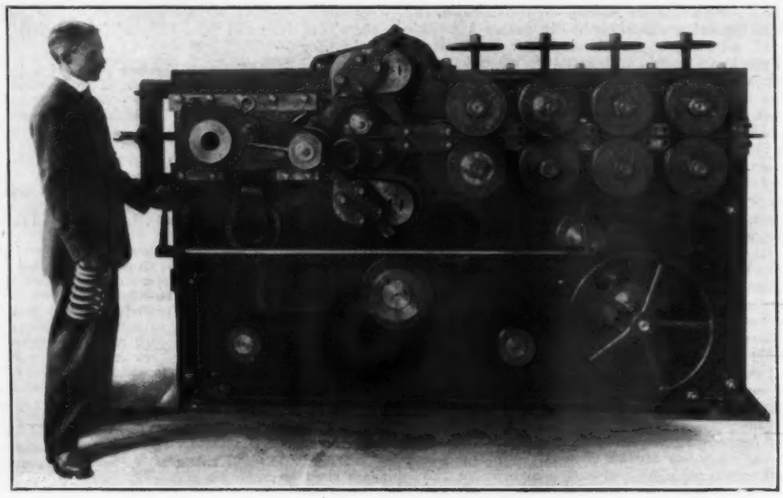


FIG. 1.

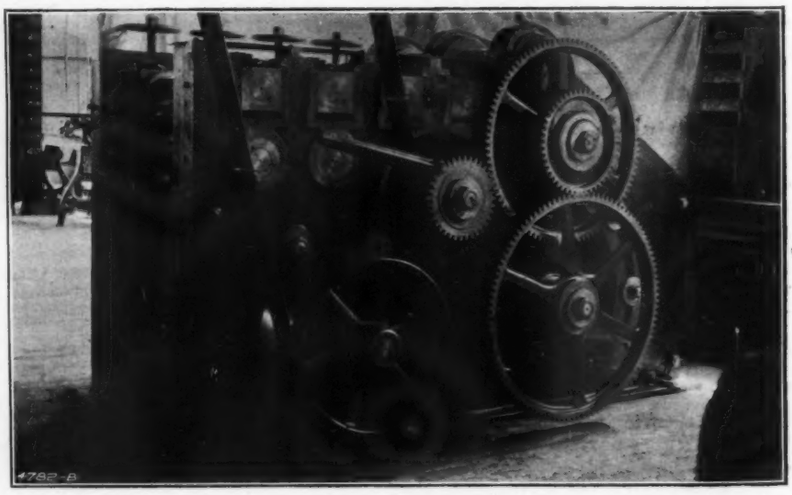


FIG 2.

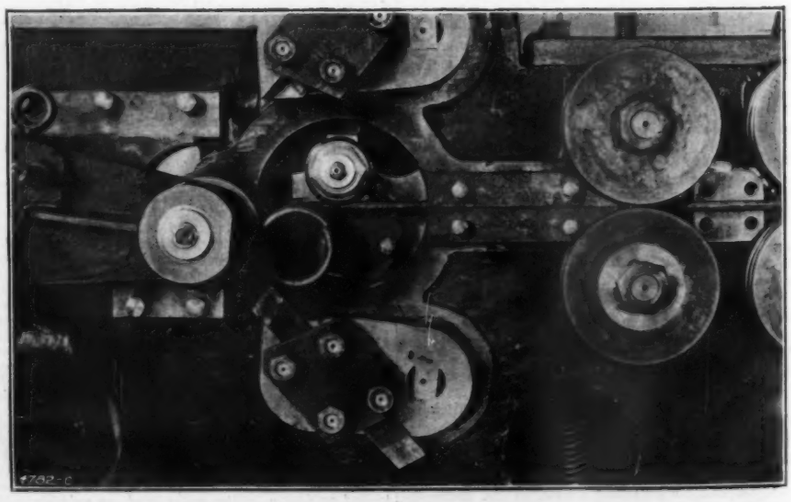


FIG. 3.

THE DENSITAMETER.

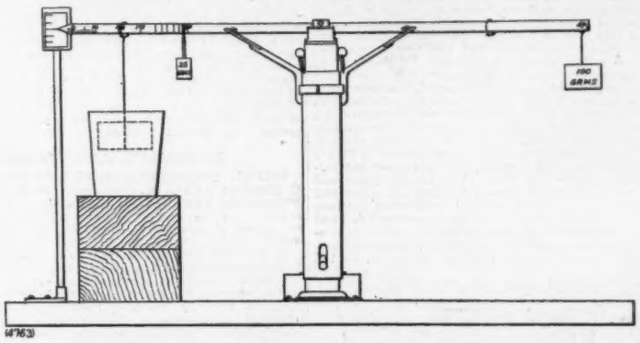
By G. A. SHAKESPEAR, The University, Birmingham.

I HAVE adopted the above name for a simple balance for finding, without calculation, specific gravities of solids; and also for detecting small differences in specific gravity (such as might be due to flaws or blow-holes in castings).

Four years ago, being asked by a manufacturer for a method of determining specific gravities (of samples of optical glass) which could be worked by a comparatively unskilled operator, I devised the instrument here described, which proved very useful in practice. Having since learned that there is a demand for such an apparatus, I give a description of it in case it may prove useful to others. The account here given applies to an instrument capable of dealing with samples of any weight between 20 and 600 grammes (say 1 oz. to 1½ lb.), but it could, of course, equally well be made on a larger or smaller scale.

The Balance.—A steel strip 21 in. long, ¾ in. wide, ⅛ in. thick, has knife-edges at its middle and near each end, as in an ordinary balance-beam, the central knife-edge being supported on a plane, and a suitable arrestment being provided to raise it from the plane when not in action. The left-hand end of the beam is pointed and moves in front of a scale attached to a mirror, which enables deflections to be observed with accuracy.

The left-hand end of the front of the beam is graduated in reciprocals of distance from the central knife-edge, thus:—The lateral knife-edge, which is 10 in. from the central one, is marked 1, while the point 5 in. from the centre is marked 2, the product of the number of any scale division and its distance from the central knife-edge being constant.



Weights.—Sets of weights are provided, each consisting of two of equal value, and others of ½, ⅕, ⅒, $\frac{1}{20}$, *e.g.*, two of 100 grammes, and one each of 50, 25, 12.5 and 10 grammes. One of the 100-gramme weights (called "the counterpoise") is fitted with two hooks, so that it can be hung on the right-hand knife-edge. All the others (called "compensating weights") are fitted with single hooks, so that any one of them can be hooked on to the beam at any point.

Method of Using.—(*a*) *Determination of S.G.*—Suppose we wish to find the specific gravity of a sample of some substance heavier than, and insoluble in, water—*e g.*, india-rubber—and that its weight is between 100 and 200 grammes. The 100-gramme counterpoise is hung on to the right-hand knife-edge so as to swing freely.

The specimen of rubber is attached by means of a fine wire to a loop of thin steel wire capable of sliding along the left-hand arm of the beam, which it embraces. The loop carrying the rubber is now adjusted by trial to a position on the beam such that on releasing the arrestment the balance is found to be in equilibrium. A vessel of water is now carefully raised under the hanging lump of rubber until the latter is completely immersed, and the vessel is supported by a block of wood. The up-thrust of the water, of course, destroys the equilibrium of the beam, but this can be restored by hooking on to the left-hand side of the beam the second 100-gramme weight and adjusting it until, on releasing the arrestment, the beam oscillates equally about the zero of the mirror scale. The specific gravity of the rubber is now read off directly on the scale on the beam.

Theoretically, exactly the same procedure could be used for a piece of iron, lead, or platinum of the same weight, but in practice it is found better to use one of the smaller compensating weights. For example, for lead the 10-gramme compensating weight would be used ($\frac{1}{10}$ of the weight of the counterpoise), and as the specific gravity of lead is 11.37, the compensating weight would be found to be at the division 1.137 on the scale, and this multiplied by 10 gives the specific gravity.

The advantage of thus using a small compensating weight is that the part of the scale used is the more open part near the end of the beam, where not only is the compensating adjustment easier to make, but the position of the compensating weight can be more accurately read. Similarly for a specimen of aluminium the 50-gramme compensating weight would be used and the number on the scale would be multiplied by 2 (*i.e.*, $\frac{1}{50}$); while for iron the 25-gramme compensating weight would be suitable and the scale-reading would then be multiplied by 4 (*i.e.*, $\frac{1}{25}$).

If the instrument were intended to be used always for one particular class of bodies of nearly the same specific gravity (*e.g.*, different kinds of brass), the scale could be numbered to give values directly, without even the simple process of multiplying by a small number. The degree of accuracy attainable by a comparatively unskilled worker is about 1 per cent., while a skilled worker can get results accurate to about 1 in 1000.

(*b*) *For Comparing Specific Gravities of Substances which are of nearly the Same Density.*—Comparisons can be made still more rapidly. For example, suppose some steel castings are suspected of having concealed flaws in the form of blow-holes. A sound casting of the same material is selected and hung by means of very fine wire to the sliding loop on the left-hand arm of the beam, and the suspected casting similarly hung to a similar sliding loop on the right-hand arm, the lighter of the two being as near the end of its arm as possible, and the heavier being adjusted to balance it. Both are now immersed in water (at the same temperature), and if the two are of the same specific gravity the equilibrium of the beam is not altered. If, however, the suspected casting has a small concealed blow-hole, its average specific gravity will be less and on immersion it will appear lighter than the sound one. In the same way it is easy for an unskilled person to distinguish between gold of different degrees of purity.

In the apparatus described 1 centigramme placed at the end of the beam produces a very appreciable deflection. Suppose the steel casting weighs about 80 grammes, it would displace about 10 grammes of water, and a blow-hole of volume $\frac{1}{1000}$ cub. cm. could be detected with ease. If the specimen weighed about 800 grammes (say 2 lb.), a blow-hole of about $\frac{1}{10,000}$ of the volume of the casting could be detected.

The back of the beam is divided from the centre into inches and tenths. This enables specific gravities in cases such as that just described (*i.e.*, when small differences from a standard are to be determined) to be compared with a high degree of accuracy. Let us suppose, for example, that specimens of an aluminium alloy are to be tested for being up to a particular standard of specific gravity. A sample of the standard is made. Suppose it is of 2.7 specific gravity and weighs 270 grammes. It will then displace 100 grammes of water. Let this be hung on one of the knife-edges and the sample to be tested be suspended and balanced as before described. Then, on immersion, suppose the equilibrium is destroyed owing to the sample being slightly less dense than the standard. A weight of 1 gramme can now be slid along the beam as a "rider" until equilibrium is restored (provided the difference of density is small enough). Suppose this occurs when the gramme weight is 5.2 in. from the centre; this implies that the specific gravity is about 5.2 parts in 1000 less than that of the standard. If it is denser than the standard, the rider must be placed on the other arm of the balance. Thus $\frac{1}{10}$-in. movement of the rider corresponds to a difference of specific gravity of about $\frac{1}{10,000}$.

Points Requiring Care.—It is, of course, important that air-bubbles should not cling to the immersed body. Iron has a marked tendency to collect air-bubbles, but I have found in practice that a previous immersion in methylated spirits greatly diminishes the trouble arising from this source. Boiled water also is advantageous as being much freer from dissolved air than water drawn directly from a tap. For very accurate work it is important that the temperature of water on the two sides in (*b*) should be the same, and that in (*a*) not much above 15 deg. Cent.

The adjustment of the position of the sample to be tested requires a little skill, especially if this be much heavier than the counterpoise. I find that it is advisable to use a counterpoise not less than half the weight of the sample; the nearer the weights of counterpoise and sample the easier the adjustment. It would be easy, however, to get over this difficulty, if desired, by moving the carrier by means of a screw running along the beam from which the sample was to be suspended, but the extra complication would not be worth while unless accurate results were required from an incompetent worker, and it is always better to educate the worker than to complicate the apparatus. An arrangement of the kind, however, would probably be necessary if the instrument were to be designed to deal with very heavy castings—some hundredweights or tons, for example.

The densitameter could evidently be arranged for use with solids lighter than water if required. There is no point in applying it to liquids, since ordinary immersion hydrometers are much simpler for this purpose. The accompanying figure shows the general appearance of the instrument described. The method of dividing the beam is, however, only indicated. The specimen on the beam is a piece of steel.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below some data on a few colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Fuller information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa.—The Imperial Trade Correspondent at Johannesburg has forwarded copies of specifications and tender forms in connection with calls for tenders by the South African Railways Administration, as follows:—(1) Up to noon on June 19* for the supply and delivery of best Yorkshire iron for a period of 12 months, commencing July 1, 1916. (Tender No. 715.) (2) Up to noon on July 3 for the supply and delivery of steel-framed structure for a goods shed at Cape Town. (Tender No. 710.) (3) Up to noon on July 3* for the supply and erection of a steel structure to form a coaling plant (500 tons capacity) at Ladysmith, Natal. (Tender No. 714.) In the case of the contract for a steel-framed structure for a goods shed, tenders will also be received up to the same date by the High Commissioner for the Union of South Africa, 32, Victoria-street, London, S.W., at which address also drawings in connection with tenders Nos. 710 and 714 may be inspected. The Imperial Trade Correspondent at Johannesburg has also forwarded a copy of a specification and tender form in connection with a call for tenders by the Johannesburg Municipal Council for the supply and delivery of spare parts required for 20-in. by 10-in. Blake-Marsden eccentric stone-breakers, comprising fixed and swing jaws, and cheek and toggle-plates. (Contract No. 135.) Sealed tenders, on the proper forms, will be received by the Town Clerk, Municipal Offices, Johannesburg, up to noon on July 3.*

* It will be observed that the time for the receipt of tenders is limited, and this intimation will therefore be of use only to firms having agents in South Africa who can be instructed by cable.

Uruguay.—The *Diario Oficial*, Montevideo, publishes a Bill proposing to authorise the Executive Power to earmark the sum of 18,000 pesos (about 4000*l.*) for the provision of drinking water to the town of Juan L. Lacaze.

THREE YEARS' IRRIGATION RESULTS.—The new Government irrigation settlements in Australia, started several years ago with emigrant settlers assisted from Great Britain, are in these days blossoming with a prosperity which would excite more attention in less stirring times. The young vineyards and orchards are making splendid returns. More railways are being built in the Nanco area of New South Wales, and at Leeton the sultana crop yielded well over a ton to the acre. The earliest sultana vines there are now in their third or fourth year. The main water channels are being lined with concrete. A canning factory has been built at Leeton, and has proved a great necessity in the heavy fruit season just passed. In addition to large quantities of fruit forwarded to the Sydney market and surrounding towns, approximately 100,000 lb. of fruit was put through the factory during December, January and February. One settler with about 20 acres of three-year-old peach trees last year realised 23*l.* per acre. As the whole of these peaches were delivered to the canning factory, this price was practically net. This season the same orchard is loaded down with fruit, consequently the settler's return should be much higher. In addition to the peaches treated the cannery has this season also dealt with considerable quantities of apricots, as well as consignments of plums, pears, strawberries, lemons (for squash and candied peel), and 91,178 lb. of vegetables, up to the end of February.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

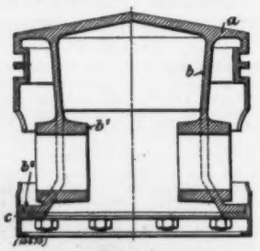
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 95, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

13,673/15. F. H. Royce and Rolls Royce, Limited, Derby. Internal-Combustion Engines. [1 *Fig.*] September 25, 1915.—This invention relates to pistons for internal-combustion engines made, in the known manner, in two parts of two different metals, and more particularly to pistons the major portion of which is made, in the known manner, of a metal of low specific gravity, such as aluminium or aluminium alloy, and it has for its object to provide a piston of a minimum weight with a wearing surface of suitable material arranged to take the major portion of the thrust due to the obliquity of the connecting-rod. According to this invention, the upper and main part of the piston is formed of a metal or alloy of a low specific gravity, such as aluminium or aluminium alloy, and to the lower end of the upper or main part a ring of cast iron or other suitable hard-wearing metal is fixed and so arranged as to take the major portion of the high-pressure rubbing contact on the cylinder walls due to the



thrust caused by the obliquity of the connecting-rod. The cap or head part a, in which are grooves to receive the expansion-rings, is made in one with, and partly overhangs, the trunk part b, which is of a smaller diameter, and carries the lugs b^1 for the gudgeon-pin. At the lower end of the part b is a flange b^2, which is of a smaller external diameter than the cap part a. The whole of this part of the piston is made of a metal of a low specific gravity, such as aluminium, aluminium alloy or the like. To the flange b^2 is fixed, by means of a series of circumferentially arranged bolts or the like, a ring c of cast iron or other suitable hard-wearing metal, the external diameter of which is the same or approximately the same as that of the part a, having regard to the different coefficients of expansion of the two metals employed. The location of the lugs b^1 for carrying the gudgeon-pin in relation to the ring c is such that the major portion of the thrust due to the obliquity of the connecting-rod is taken by the ring. (*Accepted February* 2, 1916.)

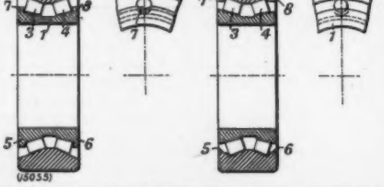
GUNS AND EXPLOSIVES.

11,731/15. Firm Schneider et Cie., Paris, France. Floating-Mines. [8 *Figs.*] July 5, 1915.—This invention has for its object to provide improved apparatus for stabilising the position of submerged floating mines. It is well known that the flow of water displaced by the hull of a ship is apt to have a deflecting effect upon submerged floating mines that may be situated in the path of the hull, to the extent of shifting the mines to such a distance as to prevent them from coming into contact with the said ship. The stabilising apparatus hitherto proposed for the purpose of opposing such deflections of the mines act solely by their mass or shape. Consequently they increase unduly the

weight or the bulk of the whole arrangement without, however, achieving the object in view, inasmuch as they prevent only incompletely the shifting of the position of the mine in the vertical and horizontal direction, and also they do not assure the prompt return of the mine into a useful position. According to this invention, a stabiliser is fitted with flexible or folding elements, capable of lying back against the framework of the stabiliser, and elastic connections are provided between the stabiliser and the mine and also between the mine and the float, the arrangement being such that the descent of the stabiliser will take place without hindrance, whereas the rising and deflection of the stabiliser from its desired sunken position will be opposed by the action of the flexible or folding elements, and the elastic connections tend to return the mine into its initial position. A, C, E, are, respectively, the mine, the float and the stabiliser. The latter is provided with clacks F and G adapted to fold back against the outer and inner sides of the stabiliser E, and also to take up a horizontal position. It will be at once perceived that in the descending movement the clacks do not offer any resistance, whereas, on the contrary, in the ascending movement they offer resistance with their whole surface. The connections D and B, which connect the mine A to the stabiliser E and to the float C, comprise elastic devices d, b respectively, which consist of springs (rubber bands or the like, metal springs, or it may be compressible bodies containing air). When such arrangement, occupying the position shown in full lines, tends to be shifted by the action of the flow of water displaced by the hull of a ship, it will be readily understood that the stabiliser that is situated at a depth out of range of the action of the flow of the displaced waters will offer to the shifting action of the said flow a resistance that is increased by the whole resistance of the horizontally extended clacks F and G. On the other hand, the stabiliser will have less tendency to be pulled away by the mine, owing to the fact that the greater part of the pulling-away strain exerted by the latter is absorbed by the elastic connection d. Similarly, the entire pulling strain between C and A is mainly absorbed by the elastic connection b. In fact, it can be assumed that the whole arrangement will have a tendency to take up the position shown in dotted lines, the stabiliser E remaining practically in its initial position. When the action of the flow of water ceases to make itself felt, the elastic connections will contract, and the whole arrangement will tend to return rapidly into its initial position. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

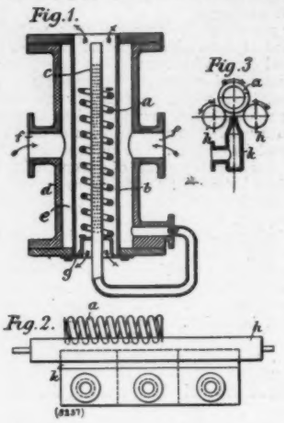
15,055/15. Aktiebolaget Svenska Kullagerfabriken, Gothenburg, Sweden. Roller-Bearings. [8 *Figs.*] December 2, 1914.—This invention relates to roller-bearings, and more especially to roller-bearings of the type wherein each bearing-ring is formed in one piece and is provided with uninterrupted races for the rollers, which latter are guided in the bearing by means of side flanges, which are provided on either one or both of the bearing-rings, and are formed integrally with said rings. The principal object of the invention is the provision of a roller-bearing of this type in a simple and suitable form constituting a self-contained unit which does not require the use of any special assembling means, and which is adapted to be inserted into various bearings for shafts, journals, wheel-hubs and the like. According to the present invention, a roller-bearing having bearing-rings, one or both of which is or are provided with flanges guiding the rollers, is provided, when the flanges are of a height less than the diameter of the rollers, with a filling-opening or filling-openings constituting recesses in the form of open channels. Referring to the constructional form shown in Figs. 1 and 2, 1 denotes the inner bearing-ring, and 2 the outer bearing-ring, each of said bearing-rings being formed in one piece and provided with conically-formed races (of which the outer and inner cones differ in the degree of slope of their sides), between which two sets of correspondingly conically-formed rollers 3 and 4 are disposed. In order to reduce the friction as far as possible, the races and the rollers are, preferably, so formed that the common apex of their conical surfaces is situated on the



geometrical axis (the axis of rotation) of the bearing. To prevent the rollers from falling out of the bearing, the inner ring 1 is formed with flanges or projections 5 and 6 disposed outside the outer ends of the rollers, the flanges being interrupted at one or more points by filling-openings 7 and 8. Through these openings the rollers may be inserted into the space between the bearing-rings. In the form shown in Figs. 1 and 2, one filling-opening is provided for each set of rollers. It is, however, feasible to omit the filling-opening provided in one of the flanges for the one set of rollers, in which case the bearing is assembled in the following manner:—First, the said set of rollers is disposed on the inner ring, then the outer ring is passed, in axial direction, on to the said set of rollers, and finally the other set of rollers is inserted through the corresponding filling-opening. The constructional form shown in Figs. 3 and 4 differs from that shown in Figs. 1 and 2 only in that the flanges 5 and 6, which prevent the rollers from falling out of the bearings, are placed on the outer ring 2 instead of being placed on the inner ring. The construction may also be still further modified by providing flanges on both race-rings. The bearings shown are adapted to carry radial loads as well as end-thrust loads in either direction. If the end-thrust in one direction exceeds considerably the end-thrust load in the opposite direction, the bearing may be of unsymmetrical form, as, for example, by so forming or shaping the parts that the generatrices of the conical races at the one side of the bearing form a greater angle with the axis of rotation of the bearing than the corresponding angle formed by the generatrices at the other side thereof. (*Sealed.*)

MINING, METALLURGY, & METAL WORKING.

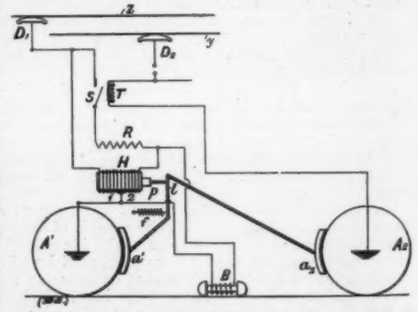
8357/15. C. P. Sandberg, London. Treatment of Steel. [3 *Figs.*] June 2, 1915.—This invention relates to a process for producing a hard and tough sorbitic structure in steel throughout its whole section, or to varying depths other than merely superficially thereof, and consists in cooling the steel moderately quickly by means of an elastic fluid or vapour from a temperature above the critical to a temperature below the critical, such that the steel or the portion thereof treated will not again be raised to the critical temperature by any heat remaining in the mass. In the arrangement shown in Fig. 1, the spring a to be treated is inserted into a tubular chamber b, through the wall of which and through a central pipe c arranged therein elastic fluid may be blown on to the spring. As shown, the tubular chamber b is arranged in a cylinder d which forms a jacket e around the chamber b, and perforations are made in the wall of the chamber b, so that if an elastic fluid under pressure is introduced into the jacket, as for instance, by inlets f, it will pass through the perforations in the chamber wall and be caused to impinge on the spring a. The centre pipe c is also preferably provided with perforations and may be connected in any suitable way to the elastic fluid supply. It may, for instance, as shown, be connected to the jacket e. The tubular chamber b is preferably left open at both ends to permit of the escape of the elastic fluid therefrom, and a support g may be arranged therein to carry the spring a. In another arrangement shown in Figs. 2 and 3, two rollers h, capable of being rotated, are mounted parallel to one another, and at such a distance apart that they will support the spring a between them when it is laid on them, as shown in the drawings. Adjacent to the rollers h and parallel to them is arranged a series of jets k adapted to direct upon the spring an elastic fluid blown through the jets. As shown, the jets k are



arranged underneath and between the rollers h, but they may be arranged in any other convenient position. In operation the hot spring is laid upon the rollers h, which are rotated rapidly, causing the spring a also to rotate, elastic fluid being at the same time blown through the jets k. In this manner the whole of the material of the spring is presented frequently to the blast of fluid. The jets k are preferably made in sections, so that one or more sections can be used according to the length of the spring to be treated. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

9915/15. The Right Hon. H. L. Samuel, W. Slingo, H. C. Gunton, and C. H. Douglas, London. Electrically-Propelled Vehicles. [1 *Fig.*] Jan. 28, 1915.—The invention relates to electric brakes which are automatically applied when the source of current is cut off from the armatures of motors driving electrically-propelled vehicles. According to the invention, a brake system is provided, comprising in combination a brake, preferably of the track type, which is automatically applied when the circuit of an armature rail-conductor is open, and an emergency brake, which is normally held off by current collected from an insulated conductor independently of the armature conductor-rail. This current energises an electro-magnet which opposes the action of a spring or its equivalent, tending to apply the brake; should the source of current be cut off from the electro-magnet, the brake is automatically applied; the emergency brake is also automatically applied if the brake, normally operating when the circuit of the armature rail-conductor is open, fails to act by reason of a disconnection in its winding or in the leads directly connected thereto. In the accompanying drawing, which represents an example of a brake system according to the invention, it is assumed that there is a field conductor-rail for energising the field-magnets, and an armature conductor-rail for energising the motors driving a train. The brake system shown is adapted for automatically braking a train without a driver, either when a braking section of the line is reached, or on the failure of the supply current. A^1, A^2 are the running-wheels on one side of a wagon, a^1 and a^2



the corresponding wheel-brakes. B is a track-brake energised by current collected by a shoe D, running on a rail z which supplies current to the brakes. S is a switch in the circuit of the brake B, which, in the example shown, is open whenever a relay T is energised from the armature rail y by the collecting-shoe D. A solenoid H, when energised over its winding 1, draws its plunger p, connected to a pivoted lever l, inwards, and thereby removes the wheel-brakes a^1 and a^2 from the wheels A^1 and A^2, against which they have been pressed by the pull of a spring f. It will be understood that the system of levers by means of which this operation is performed is shown diagrammatically only, and might be of the compensated floating type. When switch S is closed, current flows from rail z over D^1, S, a resistance R, the brake B, to earth at A^1. Winding 2 of coil H is in parallel with the winding of brake B, but in series with resistance R, and in consequence may be designed to receive but a small current while the circuit through brake B is complete. The tendency of this latter winding 2 is to neutralise the effect of winding 1, coil H, and so allow the spring f to apply the brakes. Should, however, the circuit of the track-brake B be interrupted by any failure of the connections, the current in winding 2 will be increased, owing to the decreased fall of pressure in the resistance R, and winding 1 will be neutralised sufficiently to allow the spring f to draw the plunger p towards the right and thereby apply the wheel-brakes a^1 and a^2. Should the supply of power to rail z fail, neither winding of coil H is energised, and the wheel-brakes are applied by the spring f. (*Sealed.*)